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SEP 26 1927

VOL. 18, NO. 3 SEPTEMBER, 1927

PROCEEDINGS 47TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED MONTHLY

BY THE

AMERICAN WATER WORKS ASSOCIATION

AT MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, MD.

SECRETARY'S OFFICE, 170 BROADWAY, NEW YORK
EDITOR'S OFFICE, 16 WEST SARATOGA STREET, BALTIMORE, MARYLAND

Subscription price, $7.00 per annum

Entered as second class matter April 10, 1914, at the Post Office at Baltimore, Md., under the act of August 24, 1912
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917;
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JOURNAL
OF THE
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VOL. 18 SEPTEMBER, 1927 No. 3

MANUFACTURE OF FERRIC ALUMINUM BY THE ARGENTINE SANITARY WORKS AND WATER SUPPLY

BY MARIO L. NEGRI[1] AND ATILIO A. BADO[2]

The majority of waters of both North and South America, used as water supply, is muddy and ordinarily can not be directly clarified by simple filtration through sand filters, because the matter in suspension is in the colloidal state and because the water contains dissolved humic substances which are not totally separated by the oxidation of the sand filters.

Due to these causes, the method used in North and South America, especially in the Argentine, for the purification of such waters is a combined method of chemical precipitation by means of aluminum sulphate, decantation of this precipitate and filtration of the liquid thus obtained through sand filters which have a chemical and physical action of clarification and destruction of the organic matter not precipitated by the coagulant.

The muddiness of these waters is due to the suspension or pseudo-solution of the more or less ferruginous clays which form the bed of American rivers. Consequently the aluminum sulphate, acting on the carbonates of the water and combined with the dissolved organic matter, carries into the coagulated form the clay in suspension in the colloidal state.

[1] Chief Sanitary Engineer, Obras Sanitarias de la Nacion, Buenos Aires, Argentine Republic.

[2] Chief Chemist, Obras Sanitarias de la Nacion, Buenos Aires, Argentine Republic.

In summary, the coagulant obtained is a true "laca" formed by an aluminum hydrate combined with the organic matter and mixed with clay. Theoretically and practically the aluminum sulphate in an alkaline water decomposes and precipitate the totality of the aluminum hydrate. The coagulant obtained in the settled deposit, therefore, could be used to regenerate the coagulant employed. During the year 1912 preliminary trials were made which permit us to arrive at the following conclusions:

a. The coagulant used in the clarification of river water can be regenerated from the mud which precipitates in the deposit of decantation in Recoleta's Plant.

b. This same product could be used as a base for obtaining a great quantity of sulphate, taking advantage of the same oxide in the precipitated clay.

RECOVERY OF SETTLED COAGULANT

With the object of carefully studying this problem, a series of tests were made in the laboratory by making the analyses of the mud collected in the deposit of decantation. The mud was afterwards subjected to attack with sulphuric acid.

The mud extracted contains a total of solid matter which varies from 23 to 30 per cent. This is easily deposited and a black or dark brown product of gelatinous appearance is obtained. This is concentrated little by little under the action of air and sun rays and finally after a variable time, from ten to fifteen days, under atmospheric conditions, a solid product is obtained of appreciable resistance that can be broken easily with a hammer. This product pulverized and dried out during five hours at 110°C. has approximately 15 per cent of organic matters. The rest consists of clay and aluminum hydrate easily soluble.

After a series of laboratory experiments we found that the hot sulphuric treatment of the mud previously dried and calcined at a convenient temperature and the concentration of the liquid to a state of crystallization had given a product of small yellow-white pieces of astringent taste. This product has the property of coagulating the clay of the muddy water.

This procedure was patented by the authors under patent number 12626 (Argentine Republic) and was voluntarily and gratuitously granted to the Directory of the Obras Sanitarias de la Nacion in case they decided upon the manufacture of such a product in this country.

Later investigation by Dr. Bado made it possible to substitute for the use of the mud of the settling basin the Pampeano loess, which is found in large quantities under the vegetal cover in the federal state, Province of Buenos Aires, and in other points. This new method permits simplification of the factory installation and the manufacturing process, eliminating at the same time a series of manipulations otherwise necessary, by using the raw material obtained at comparatively low price.

MANUFACTURE OF ALUMINO FERRIC

The Technical Directory of the O. S. N. reported to the Directory of the same Institution requesting the sum of $443,850 (Argentine Currency, equivalent to $177,540, American Currency) for the installation of the alumino ferric plant (on the basis of the Pampeano loess as the raw material) with the capacity to produce 10,000 tons per year.

During the meeting held by the Directory of the Institution on June 23, 1916, it was resolved to approve the plan and the preliminary works presented by the Technical Directors for the installation of the alumino ferric plant and to request of the Ministerio de Obras Publicas (Secretaryship of Public Works) the necessary authorization for the investment of funds.

The Executive Power of the Nation on July 3, 1916, gave out a decree authorizing the installation of the factory on the Recoleta Plant. The construction work began immediately and on April 23, 1917, the factory began its operation uninterrupted up to this date.

SIMILAR INDUSTRIES ELSEWHERE

At the time of finishing the authors study we were informed of the appearance of an article in Engineering Record, May 8, 1915, under the title of "Columbus Water Works is making its own alum-A revolutionary step in water purification practice," by Charles P. Hoover.

From its contents it appears that the project of reference is similar in all its general principles to the one we have worked out. Our idea of manufacturing the coagulant in this country dates back to the year 1912, in other words 3 years before it was applied in Columbus.

In Columbus they used bauxite, substituting after a while "halloysite."

In Kinston-on-Thames the municipality manufactures the alu-

minum sulphate, employing the bauxite for the purification of its water. This manufacture dates from 1910.

The manufacturing process developed by us differs from the Columbus one in the raw material. We were obliged to have recourse to the pampeano loess, after fruitless attempts to find the bauxite in this country. The adoption of loess is analogous to the Columbus idea to substitute the halloysite for the bauxite.

RAW MATERIAL USED

The raw materials used for obtaining ferric aluminum are: the pampeano loess and the commercial sulphuric acid.

The formation of the pampeano loess is still subject to numerous discussions and nothing is truly known respecting it. Some think

TABLE 1

Composition of the pampeano loess

COMPONENTS	1	2	3	4	5	6
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Silica (SiO_2)	70.58	69.40	70.74	69.62	71.98	69.00
Aluminum oxide	17.70	16.00	16.70	17.80	17.40	16.70
Iron oxide	7.00	7.00	7.00	7.00	6.70	7.20
Calcium oxide	2.26	2.24	2.47	2.42	1.85	3.33
Magnesium oxide	1.83	1.48	1.54	1.51	1.26	1.94
SO_3	0.48	0.99	0.65	0.79		0.44
Alkalies	0.15	2.89	0.90	0.86	0.81	1.39
Loss due to calcination	2.71	3.83	3.21	2.30	2.90	3.28
Water	17.85	14.24	16.89	14.65	16.20	18.00

that the loess is the result of accumulation of dust carried by the wind; others that it is alluvial soil. It is formed by a mass of red-yellow color more or less intense according to its state of humidity, and it is easely broken by finger pressure. It can be kneaded with water and gives a plastic chocolate-colored mass. Chemically it is a double silicate of iron and aluminum.

It is found in abundance in our country on the pampeano formation. From analysis of several specimens near San Isidro Town (Province of Buenos Aires) it shows the results in table 1.

From the inspection of table 1 it may be seen that the loess utilized is of constant composition. The aluminum oxide is 17 per cent and the iron oxide is 5 per cent, with negligible quantities of calcium and

magnesium oxides. The calcium oxide is found in the mineral in the calcareous state. It is hard and cannot be pulverized by the disintegrator, which means that in the acid treatment it is covered with a layer of calcium sulphate which prevents complete attack of the mass.

The water content of the product is variable according to the hygroscopic state of the atmosphere, but in general it may be said that, in a normal surrounding atmosphere of humidity, the water absorption is 15 per cent. This product is spontaneously dried out and its humidity at the time of being employed is not greater than 10 per cent, facilitating thus the disintegration of the material under consideration.

The sulphuric acid utilized is the commercial acid from lead chambers. At present it is furnished by the sulphuric acid factory and is transported by automobile truck to the aluminum factory.

The sulphuric acid has the grade of 55 to 56.5 equivalent to 70 per cent of pure acid. The determination of the grade in Beaumé scale is made in every shipment of the acid and periodically the complete analysis is made in our own laboratory.

At present the sulphuric acid is obtained at the price of $33.48 and $31.10 during the years 1924 and 1925, respectively.

DESCRIPTION OF THE CHEMICAL PROCESS OF MANUFACTURING

The ferric aluminum manufactured is made by treating the pampeano loess with the chamber sulphuric acid at a convenient temperature.

The sulphuric acid is warmed up by means of steam produced in a boiler under from three to four atmospheres of pressure. When the temperature of the acid is higher than 100°C. it is stirred by compressed air during the time of loading the mineral. This operation is done by hand. When the mass is perfectly homogeneous the injection of compressed air is eliminated and the heating continued until 110°C. is reached. At this moment the steam injection is stopped because heat is maintained by itself for a space of more than twenty hours. When the mass is clearly attacked and the cake presents the normal appearance the extraction of the ferric aluminum begins by means of separate washings with cold water strongly stirred with compressed air. The washing is finished when the liquid shows the corresponding density. Before proceeding to the extrac-

tion of the liquid from every washing it is allowed to settle and, by means of a piping system, the liquid is carried to the decanters where it remains quiescent for twenty-four hours.

The operation is carried on by putting in each hopper 6000 kgm. of mineral, 2500 kgm. of sulphuric acid from the lead chambers, and a sufficient quantity of water to obtain a fluid mass. The acid action lasts about twenty hours. After this period the dissolution of the ferric aluminum occurs having been formed by four washings stirred by compressed air; the two first washings are done inside the hopper and the last ones in the washing reservoirs described below. In this way all the product is extracted and finally a yellow-brown liquid is obtained containing about 15 per cent of aluminum and iron sulphates. Under these conditions we obtain the results for every washing shown in table 2.

TABLE 2

Aluminum ferric obtained at different washings

WASHINGS	HOPPER NO. 1	HOPPER NO. 2	HOPPER NO. 3	HOPPER NO. 4	HOPPER NO. 5
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*
1	2,988	3,047	3,139	2,648	3,067
2	702	647	742	816	869
3	425	449	524	485	455
4	144	85	138	98	132
Total ferric aluminum...	4,259	4,228	4,543	4,047	4,523

The liquid obtained from all these operations is sent to the decanters where, by settling, it deposits the fine clay in suspension in it. The clarified liquids provide a concentrated coagulant solution that may be directly injected into the water supply for its clarification.

For this purpose the liquids from the decanters are sent to big tanks where they are stored and utilized as needed, being injected in calculated doses.

A part of the liquids, instead of being sent to the tanks, is sent through lead pipes to the concentrator tank. In this one, a water stream circulates in the lead pipes placed near the bottom. The continual evaporation concentrates the liquid from 16° to 18° Beaumé to 60 to 66°B.

The idea is advisable of not concentrating the coagulant for the

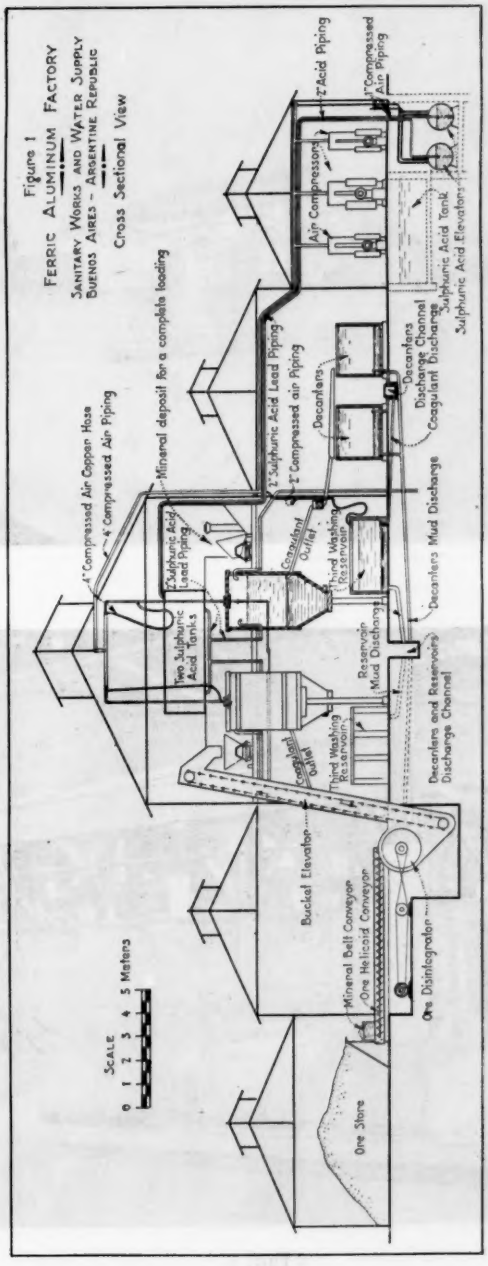


Figure 1
Ferric Aluminum Factory
Sanitary Works and Water Supply
Buenos Aires - Argentine Republic
Cross Sectional View
Scale
0 1 2 3 4 5 Meters
Mineral deposit for a complete loading
4" Compressed Air Copper Hose
4" Compressed Air Piping
Two Sulphuric Acid Tanks
2" Sulphuric Acid Lead Piping
Coagulant Outlet
Third Washing Reservoirs
Reservoir Mud Discharge
Bucket Elevator
Mineral Belt Conveyor
One Helicoid Conveyor
Ore Disintegrator
One Store
2" Sulphuric Acid Lead Piping
2" Compressed air Piping
Decanters
Decanters and Reservoirs Discharge Channel
Decanters Mud Discharge
2" Acid Piping
Air Compressors
1" Compressed Air Piping
Decanters Discharge Channel
Coagulant Discharge
Sulphuric Acid Tank
Sulphuric Acid Elevators

FIG. 1

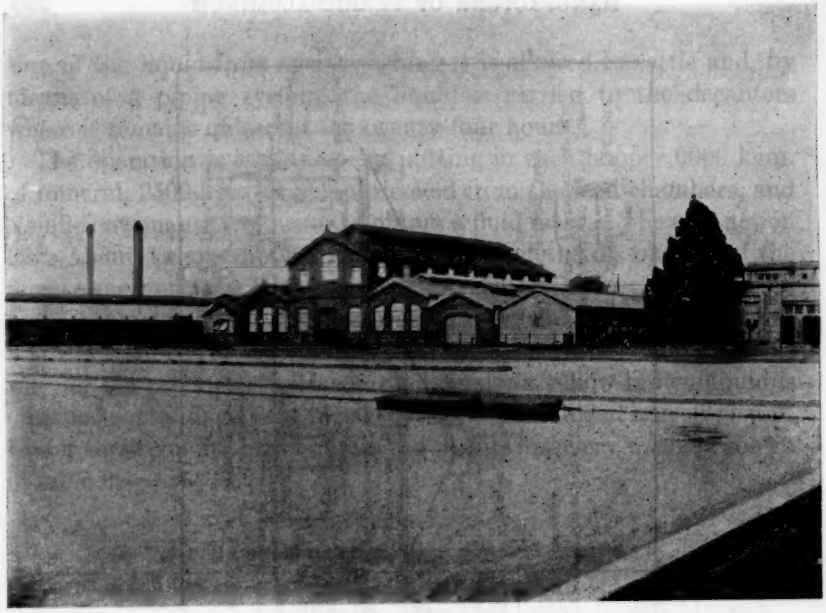


FIG. 2

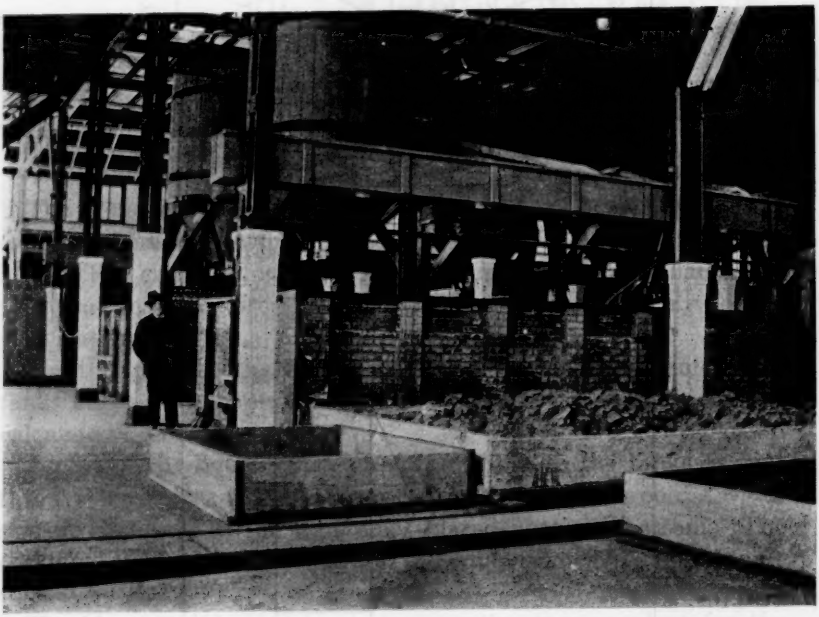


FIG. 3

FIG. 4

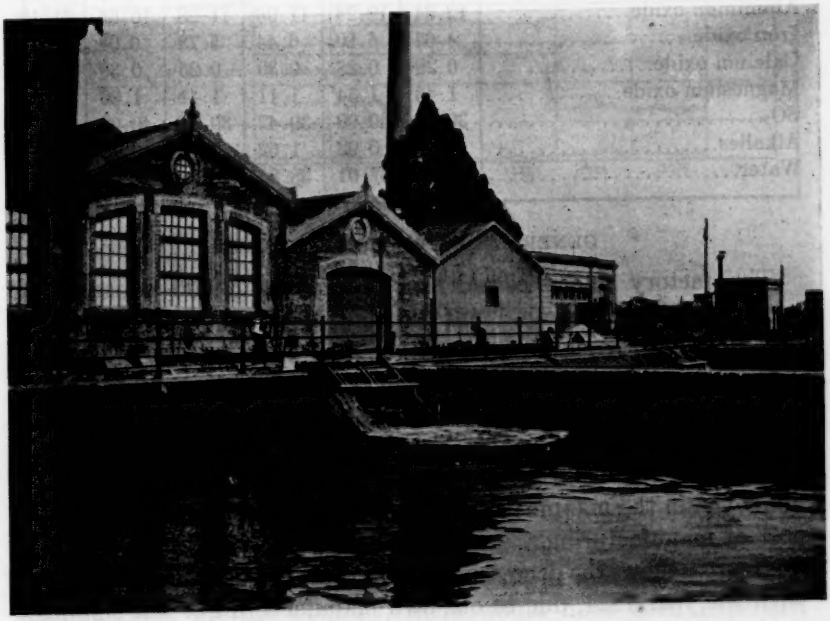


FIG. 5

Federal State, which constitutes more or less 93 per cent of the actual consumption, for the great economy of coal and hand work in the elimination of those two operations. At the same time it decreases enormously the expenses in transportation, breakage in dissolution of the solid coagulant.

The liquid once concentrated, we obtain a syrup of 60° to 66°B. of a green-yellow color which, on cooling, solidifies into a compact light green mass; breaking it by hammer it can be pulverized in a special triturator, obtaining thus a white fine powder, very lightly blue, of astringent taste, soluble in water giving a yellow solution that has the coagulant properties; that is, when poured into the River Plate water it can provoke coagulation.

The composition of the solid matter we have just described is shown in table 3.

TABLE 3

Composition of the solid ferric aluminum

	1	2	3	4	5	6
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Insoluble in water	0.72	1.31	1.20	1.70	0.55	1.08
Aluminum oxide	12.34	12.24	11.06	11.28	10.66	11.10
Iron oxide	4.62	5.80	6.44	5.78	6.04	5.76
Calcium oxide	0.29	0.28	0.30	0.25	0.30	0.31
Magnesium oxide	1.46	1.54	1.11	1.41	1.30	1.51
SO_3	39.63	40.90	39.42	39.01	40.92	39.62
Alkalies	1.72	0.92	1.62	0.56	0.73	0.92
Water	39.22	37.01	38.85	40.01	39.50	39.00

GENERAL DESCRIPTION OF PLANT

The factory under consideration occupies 23,000 square feet, located in the Recoleta Plant in front of the new decanters and between the pumping machinery building and the filters. Figures 1 to 5 show the general arrangement of the plant.

PRODUCTION COST

Table 4 shows monthly curves of sulphuric acid cost and of the ore employed in the manufacture of ferric aluminum. It also shows the cost of manufacturing.

Figure 6 shows the decreasing cost of the ferric aluminum beginning with the year 1924, due to our own manufacturing of the sulphuric acid the price of which has proportionally decreased.

Table 4 shows the yearly details of the manufactured products, the total cost of manufacturing and the unit cost of ferric aluminum. The total amount produced up to the end of 1926 is 123,334.62 tons at a total cost of $7,224,401.47 (Argentine currency), the average cost being $53.98 per ton, or $21.59 (American) per ton.

COAGULANT EFFICIENCY

The efficiency of the manufactured ferric-aluminum as a coagulant is practically perfectly demonstrated by the amount used in the plants belonging to the O. S. de la N.

A comparison of the average doses of coagulant shown in the yearly report of the Institution shows that they have not varied markedly. It must be noted that down to the middle of year 1917 the coagulant consumed was from foreign countries.

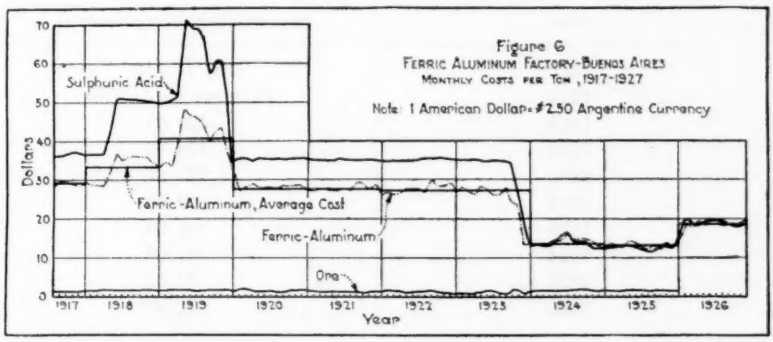


FIG. 6

ECONOMIC RESULTS

The cost of manufacturing the coagulant up to December 31, 1926, reaches the amount of $7,224,401.47 (Argentine currency). We must note the great economy to the State on account of the installation of this process.

The price of the foreign aluminum sulphate taken from the public purchases and the quotations since 1917 until 1925 varies between $420 to $70.50, as shown in table 5.

Calculating then the cost of the coagulant in case it had not been manufactured in this Country, there would have been expended annually the amounts shown in table 6.

TABLE 4

YEAR	TONS	TOTAL COST IN DOLLARS (ARGENTINE CURRENCY)	UNIT COST IN DOLLARS (ARGENTINE CURRENCY)
1917	3,274.12	236,188.69	72.13
1918	7,342.14	614,021.57	83.63
1919	9,341.20	949,991.96	101.69
1920	8,983.10	616,599.98	68.64
1921	10,491.70	727,103.65	69.50
1922	12,296.26	846,474.54	68.84
1923	15,309.28	1,058,943.10	69.17
1924	15,681.20	539,249.44	34.39
1925	19,053.00	635,767.47	33.37
1926	21,562.41	1,000,061.07	46.38

TABLE 5

Price of foreign aluminum sulphate

YEAR	DOLLAR (ARGENTINE CURRENCY)
1917	281 to 450
1918	Without quotation
1919	420.00
1920	156.83
1921	175.27
1922	99.90
1923	91.00
1924	91.00
1925	70.50
1926	72.60

TABLE 6

Probable costs of purchased aluminum (Argentine currency)

	TONS	DOLLARS PER TON	TOTAL (DOLLARS)
1917	3,274.120	281.00	920,027.72
1918	7,342.141	281.00	2,063,141.62
1919	9,341.203	420.00	3,923,306.26
1920	8,983.100	156.83	1,408,819.57
1921	10,490.700	175.27	1,838,704.99
1922	12,296.260	99.90	1,393,144.75
1923	15,309.283	91.00	1,426,989.20
1924	15,681.200	91.00	1,343,236.50
1925	19,053.000	70.50	1,343,236.50
1926	21,562.413	72.60	1,565,431.17

As we have already stated, instead of spending $17,226,038.22 in the purchase of 123,333 tons of coagulant, we spent $7,224,401.47 due to our own manufacturing, representing thus a total saving of $10,001,636.75 equivalent to $1,000,163.67 for each one of the 10 years of manufacturing or approximately $400,000, U. S. currency.

The great advantages obtained by the Nation through this industry may plainly be seen and they will be still greater on account of the future enlargement to be made in the acid factory, in order to obtain a capacity of 60 tons every 24 hours.

THE IMPOUNDING WORKS OF THE SAN DIEGO WATER SYSTEM[1]

By R. C. Wueste[2]

Even the most causal consideration of the climate, topography and geology of San Diego County discloses that the sources of available water supply for the City of San Diego within a fifty mile radius are very limited. In this sector, there are no perennial streams or natural lakes. Ground water in any quantity is pretty generally confined to the narrow ribbons of water-bearing drift forming the valley floors of the main drainage channels which score the county from the crest of the Coast Range on the east to the ocean shoreline on the west.

Although San Diego is not limited to seek water within fifty miles of her population center, it is nevertheless a fact that other sources of worth-while proportions are only to be reached by going four times that distance.

Confronted by these conditions and limitations, the one logical process of developing a dependable supply within the county has been adopted. This implies the construction of dams at favorable basin mouths, in which the locality fortunately abounds, for the impoundment, retention and storage of the winter runoff resulting from the impressment of the rainy season storm clouds upon the inclined plane of the county watershed area. The County of San Diego is a noteworthy example of the application of the principle of artificial lake creation to transmute an erratic surface source of supply resulting from the vagaries of scant seasonal rainfall, into dependable and regulated gravity duty. The first applications of this principle of development date back forty years and had their origin in the forced realization of the futility of any other means of producing adequate supplies.

[1] Presented before the California Section meeting, October 28, 1926.

[2] Supervisor, Municipal Impounding System, San Diego, California.

POPULATION GROWTH

Rapid population growth of Pacific Coast communities has furnished many surprises. The case of Los Angeles has been nothing short of phenomenal. In a twenty-year period from the time she was San Diego's present size of 150,000, her population increased to three-quarter million inhabitants, an average population increment of 30,000 per annum. San Diego's present sustained growth is about one-half this rate, with good reason to believe that it will soon approach a rate equal to that of Los Angeles. County or regional population increase is noted to continue parallel with the City's growth, so that it is evident that local water developments must follow one another in rapid succession.

COUNTY WATER RESOURCES

The runoff producing area of San Diego County comprises a 30- to 40-mile wide belt of mountainous territory mainly of granitic composition, defined on the east by the divide overlooking the Imperial Valley and on the west by the line of nearest-the-coast dam and reservoir sites. The area east of this divide is arid and almost rainless except for summer thunder storms. It drains to the east away from San Diego, falling away very abruptly from elevations between 4000 and 6000 feet to elevations below sea-level in Salton Sink. This line of demarcation between the area of highest county rainfall of 40 inches and the area of almost no rainfall is astonishingly distinct. Rainfall west of this line of dam-sites is 10 inches or less.

The county watershed area is about 2000 square miles. Areas lying north of the county boundary line in the Santa Margarita Basin and south of the international boundary line in the Tia Juana Basin which may be considered tributary to San Diego, bring the total to 3585 square miles. The most reliable estimates show that this area when fully developed, will yield a little less than 200 m.g.d., considering surface water only. Ground water sources are regarded as emergency supplies and, if used as such, can be shown to increase materially the safe net yield limit just quoted.

At present San Diego County's water supply is about one-fifth developed from the storage and correlative safe net yield viewpoints. The chief reason why the runoff producing area in the county is not fully developed today is that of cost. Although in other sections of the United States, water development can be and is made in advance

of population,—here, on account of its high cost, such development must wait upon the influx of people and money. However, the rapidly increasing preciousness and demand for water will compel complete development within twenty years.

FINANCIAL LIMITATIONS

To carry these general statements just a little farther, the local quantitative relationship between population and safe net yield of water supply, is that 10,000 people require 1 m.g.d. of safe net yield at 100 gallons per capita per day, including all municipal uses.

Monetarily, San Diego's assessed valuation of property has corresponded very closely to her population curve with a ratio of about $1200 per capita. Only 15 per cent of this is available for bonding for all purposes. When it is realized that the capitalization by means of bond issues of the city's present supply works of reservoirs, dams, transmission, distribution works and appurtenances averages one million dollars per million gallon daily of safe net yield, the intricacies and limitations of the local problem, other than physical, tax the utmost ingenuity of the hydraulic engineer.

HISTORY AND DESCRIPTION OF CITY'S WORKS

San Diego's water supply problem began of course with the first settlements here. During the rainy season the arroyas and ravines held living water. The rainy season over, the creek bottoms furnished ground water for the nuclear community and pioneer agriculturists. The padres who founded the San Diego Mission in the late eighteenth century at the upper end of Mission Valley developed a diversion gravity supply for the needs of the Mission, the boldest attempt for a hundred years to produce a water supply independent of the vagaries of rainfall. With the settlement, in 1867, of "New Town," where San Diego's business section stands today, and the hectic boom of 1886-1887, well supplies within the city limits were quickly seen to be inadequate. The pioneer storage developments on the San Diego and Sweetwater Rivers followed. Conception of similar developments all over the county dates back to this period. The collapse of the boom, the drouth of the late nineties ending in 1904, the community's struggle for existence, the reversion to the Mission Valley sands for a city water supply, the far-sightedness and resources of the late Mr. Spreckels in developing the Cottonwood-Otay supply, the City's gradual awakening from lethargy and its

final irresistible momentum and accelerated growth, justifying and making necessary all the later developments—form colorful and romantic epochs in local water development history.

At the present time we find partial development of the San Luis Rey, San Dieguito, San Diego River, Sweetwater, Cottonwood and Otay drainage areas, presenting dams and accessory structures of a variety of types. The City at the present time owns and controls the dams and reservoirs on the San Dieguito, Cottonwood and Otay drainage basins and accessory structures, serving same, as shown in tables 1 and 2.

With due respect for the admirable work of local pioneer engineers and promotors, some of their efforts indicate errors in judgment, due

TABLE 1

Dams and reservoirs

NAME	TYPE	HEIGHT ABOVE STREAM-BED	YEAR BUILT	COST	RESER-VOIR CAPACITY	SAFE NET YIELD
		feet		*dollars*	*m. g.*	*m. g. d.*
Morena	Loose rock fill	166	1912	1,400,000	17,492.8	4.0
Barrett	Concrete gravity arch	179	1922	1,650,000	14,512.2	4.4
Upper Otay	Concrete arch	80	1901	80,000	835.7	0.5
Lower Otay	Concrete gravity arch	149	1919	745,000	18,979.5	3.3
Chollas	Earth fill	46	1906	70,000	90.7	
Hodges	Concrete multiple arch	130	1918	500,000	12,284.3	4.3
San Dieguito	Concrete multiple arch	51	1918	50,000	368.6	

probably mainly to lack of reliable data on runoff. The productivity of watersheds and the resultant safe net yield of developments were in instances greatly overestimated. It is not to be wondered at that certain developments have been put in with little regard to adhering to a logical schedule of sequence. Today, the wealth of engineering reports on the local water supply problem and the cumulative record of performance of watersheds and reservoirs makes possible a fairly accurate analysis of the local situation.

It was not until very recently, however, that a plan of development by the city was formulated by city manager, F. A. Rhodes, detail-

TABLE 2

Accessory structures

NAME	TYPE	DESCRIPTION	YEAR COMPLETED	COST	CAPACITY
				dollars	
Dulzura Conduit Extension	Concrete lined canal	6.29 miles trapezoidal ditch, box syphons, metal flumes, concrete drops	1915	185,000	40.0 m.g.d.
Dulzura Conduit	Concrete lined canal	11.0 miles trapezoidal ditch, wood flume and tunnel, grade 0.08 per cent, bottom unlined	1909	521,000	40.0 m.g.d.
Lower Otay Filtration Plant	Rapid pressure	24 8 x 20 horizontal units	1915	125,000	12.0 m.g.d.
Otay-San Diego Pipe Line	Continuous woodstave and cast iron	19.15 miles compound line, 40-inch, 36-inch, 34-inch, 32-inch, 30-inch, 24-inch	1906	529,000	7.8 m.g.d.
Bonita Pipe Line	Riveted steel	8.08 miles 28-inch No. 0 Riveted steel	1915	220,000	6.8 m.g.d.
Chollas Booster Pump	Electric centrifugal	Double suction 2 stage 250 h.p. motor	1914	15,000	12.0 m.g.d.
Mission Valley Pumping Plant	Electric centrifugal	12 4-inch, 4 stage vertical 10 h.p. and 2 10-inch, 4 stage 250 h.p.	1914	100,000	5.0 m.g.d.

Hodges Conduit	Concrete lined canal	4.65 miles trapezoidal ditch, circular reinforced concrete syphons, metal flumes	1918	200,000	9.7 m.g.d.
Lockwood Mesa Gravity Line	Reinforced concrete pipe	6.72 miles 24-inch, 26-inch, 27-inch reinforced circular concrete pipe	1918	108,209	3.9 m.g.d.
Lockwood Mesa Reservoir	Open concrete lined	Trapezoidal concrete lined basin, 60 x 100 bottom, 84 x 124 top, 8 feet deep	1918	10,000	0.5 m.g.
Del Mar-La Jolla Pipeline	Machine banded wood-stave and reinforced concrete	10.55 miles 16-inch and 18-inch diameter	1920	200,000	3.5 m.g.d.
Torrey Pines Reservoir	Open concrete lined	Square trapezoidal concrete lined basin 200 x 200 bottom, 230 x 230 top, 10 feet deep	1920	25,000	3.0 m.g.
Torrey Pines Filtration Plant	Rapid pressure	7 8 x 20 horizontal units	1926	40,000	3.5 m.g.d.
Torrey Pines Booster Pump	Electric centrifugal	3 6-inch, 2-stage pumps; 3 125 h.p. motors	1926	8,000	4.5 m.g.d.

Note: The above list does not include the distributing system within the city, or its accessory standpipes, service reservoirs, filter plants and booster pumps.

ing step by step the proposed developments for the next twenty years which will keep the safe net yield available to the city ahead of the expectancy curve of population. This strategical denouement of the latent resources embraces progressive and complete development of the San Dieguito, San Diego and Tia Juana drainage areas.

PROBLEM OF SAFE NET YIELD

One of the most interesting and engrossing phases of local hydraulic engineering research is that of safe net yield and its allied subjects. Safe net yield may be defined as the quantity of water which a development will yield for continuous withdrawal, under continued climatic conditions in the future, similar to those of which we have record in the past.

The first of these conditions is rainfall, records of which at San Diego date back seventy-five years. The mean seasonal rainfall at San Diego is less than 10 inches, increasing about one-half inch with each 100 feet of topographical altitude to the eastern rim of our watershed area.

The characteristics of this rainfall are the erratic, gross seasonal variations from the mean and the erratic occurrence of the rainstorms which go to make up the gross seasonal totals. The seasonal variations have run 50 per cent below mean and 250 per cent above mean.

The relationship between rainfall and runoff is far from direct or uniform. During subnormal seasons of rainfall, no runoff whatsoever has been known to reach a given reservoir, all rainfall being dissipated by the operation of such factors as capillary retention and vegetable transpiration. Under certain storm conditions it might happen that all the rainfall descending upon a certain area would reach a given measurement plane as runoff. This residual coefficient may then lie somewhere between 0 and 1, and runoff from certain drainage basins has actually been found to vary from nothing to ten times the seasonal mean which for the county watershed area is about 120 acre feet per square mile. Maximum runoff rates are estimated as high as 400 second feet per square mile.

Once the runoff has been harvested behind one of our dams, the factor of evaporation immediately becomes operative. Evaporation is classified as gross and net, the latter being gross evaporation as offset or diminished by rainfall descending upon the same reservoir surface from which the evaporation has taken place, in the same time period. Since both evaporation and rainfall increase with altitude, the net evaporation is somewhat uniform for all portions of the county.

The controlling influences on safe net yield are, therefore, the size and mean altitude of the tributary watershed, the size or impounding capacity of the control reservoir, ranging in ultimate developments between 4 and 6 billion gallons per million gallon daily, and its efficiency index, that is, the ratio of its volume to its exposed surface area. Reservoirs can and do differ greatly in this latter characteristic, which in turn affects reservoir performance.

The city is in possession of reservoir performance computations on practically every constructed and potential development in San Diego County. These computations necessarily predicate certain factors upon which there is no observation or record from other factors upon which there is observation or record. The computations may with safety be commenced with the 1883–1884 season, the greatest locally within the period of rainfall records, and if safely carried over the critical dry period 1897–1904, will represent safe net yield in accordance with the definition before given. In general, the major developments of the county will show a safe net yield of between 40 and 50 per cent of the mean seasonal runoff.

Often it may be shown that storage adjustment or transfer from one reservoir to another is advisable from a standpoint of monetary economy or water loss prevention. Such adjustment is made annually on the city's Cottonwood Otay System and is contemplated on the Sutherland, San Vicente and El Capitan projects.

COST OF DEVELOPMENT

From all the preceding, it is evident that the cost of water locally must be high. Collection and transmission properties operated and controlled by the city have been acquired under bond issues and equivalent payments, totalling $11,000,000.00. Bonds on the distribution system represent another $3,000,000.00 investment. This capital investment represents over $600,000.00 of interest annually, at the interest rates on the actual bonds, most of which are not yet redeemed. The most recent figures place the cost of water at the tap at 24.1 cents per 1000 gallons. This may be segregated into

	CENTS	PER CENT
Interest	12.05	50
Depreciation	4.82	20
Maintenance and Operation	7.23	30
	24.10	100

The city is 100 per cent metered and the selling price of water is 20 cents per 1000 gallons. The excess of cost over selling price naturally is met in the tax levy on assessed valuations. In the past, this procedure was regarded as advisable, in view of its effect on the non-user holding vacant property.

Locally, the day of cheap water properties or water rights is past. As water becomes more precious the cost and valuation of these fundamentals will increase.

RECREATIONAL USE

Contrary to general practice elsewhere, San Diego allows recreational use by the public of its impounding reservoirs. The practice is in fact universal in the county and has a commercial aspect which is increasing in importance, at least as fast as regional population growth.

The physical factors surrounding the local methods of water development account for our ability to continue this practice with no deleterious effect upon the quality of the water. It appears that sparsely populated watersheds, large reservoirs, long storage (from one to ten years) common sense restrictions and ample sanitary facilities for the hunters and fishermen may perpetuate this unique privilege to our citizenry.

QUALITY OF DEVELOPED SUPPLY

The same factors which encompass and make difficult and expensive the development of water for San Diego, fortunately also are accountable for its high purity and attractive esthetic quality. Watersheds of granite formation and by nature not fitted to dense agricultural population and subject to nine months' natural sterilization by air and sunlight, long storage implying immolation of bacteria are responsible for the high quality of the raw water.

With efficient plankton control, color, odors, and tastes may be kept to a minimum.

Surface temperatures follow a curve during the year similar to the mean air temperature. Draft is usually advisable from the upper strata of our reservoirs. Transmission to the city does not change these temperatures materially. In consequence, we receive water as warm as 80 degrees at our taps in midsummer and as low as 57 degrees in winter.

Even with a raw water suitable for consumption without any

treatment, San Diego employs the purification processes of rapid sand filtration and chlorine disinfection. Three separate filtration plants are in use on three of the arteries entering the city. They are all of the pressure type and represent the greatest number of units employed on municipal water anywhere in the United States. Disinfection follows filtration.

San Diego's position on the honor roll of the seventy-seven American cities with over 100,000 population and her first position in the group of ten Mountain and Pacific state cities of that size in the 1925 typhoid fever survey of the American Medical Association speak with significant eloquence of the purity of its water supply.

CONCLUSION

We feel that nowhere in the United States is the question of water supply development of greater vital importance to a growing community, endowed with many other and diversified blessings, than in San Diego. Local development is but a fourth as old as developments elsewhere in the United States, yet we feel that here man's interference has shapen the development of a supply in greater measure than where water is less precious.

The involved relationship of the limited and sporadic natural gift of rain and the high cost of control and conversion of the resulting runoff to sustained duty is unique and intensely interesting. Forty years ago the first settlers' needs stood impotently by, while wild floods coursed to the sea. Step by step our water history will show these same floods brought to rest and released as silver threads for the community's use, growth and advancement.

RECORDS OF THE PERFORMANCE OF SMALL METERS[1]

By W. E. MacDonald[2]

To meter successfully the water of any city requires the organization of a separate branch of the service whose duty it is to set, test, read, repair and build up a system of cost records. The records compiled should be complete in all details so as to permit a ready analysis of all types of meters, both as to their cost of maintenance and accuracy in service.

The water meter of to-day is a unit used for the measurement of water. It is vitally important that this unit maintain its accuracy during its lifetime, for its failure results either in the water company delivering water for which no money is collected or the private consumer is charged for water which he does not receive. Neither of these conditions are desired by the responsible head of water departments. It is with these thoughts before me that I present a system of costs and accuracy tests for the guidance of a water department, to maintain a high degree of accuracy in the registration of its meter at a minimum of cost.

Preserving records of the cost of any work is valuable of itself because it reveals a cost of the particular undertaking, but that alone is of minor importance compared with the valuable information gained from such records when applied to some new scheme. This is equally true in water meters. The information gained from duration tests, extending over a period of many years of various makes of meters, is a source of valuable information at the time of purchase of new meters.

To purchase water meters intelligently it is essential to have data on the following important factors.

Costs:
  a. Initial
  b. Maintenance
Results of tests for:
  a. Pressure, loss of head, capacity and accuracy in service

[1] Presented before the Buffalo Convention, June 10, 1926.

[2] Engineer, Water Works, Ottawa, Can.

Unless the buyer has previously purchased meters of all types and has a definite record of each in service, he is not in a position to judge the relative merits of meters as to cost of maintenance and accuracy in service. While it is quite true that any new meter may be tested for accuracy and sensitiveness on small flows and a comparison made of meters tendered on, yet, in the opinion of the writer, such tests are not of much importance, for, when new, all meters can be made accurate and sensitive to a degree, but it is only after a long period of service that the actual merits of the various meters may be determined.

To be in possession of full information covering all types of water meters it is recommended that two complete sets of books be maintained, one showing a record of the consumption to all premises under

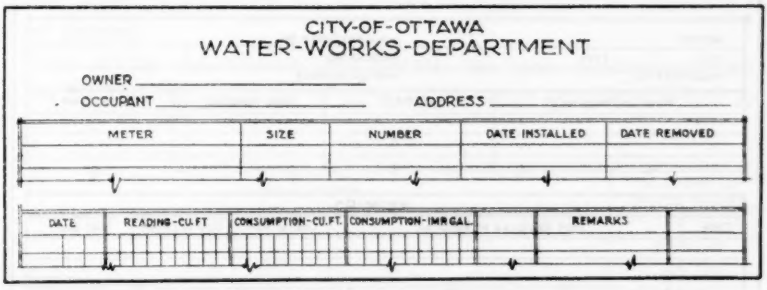


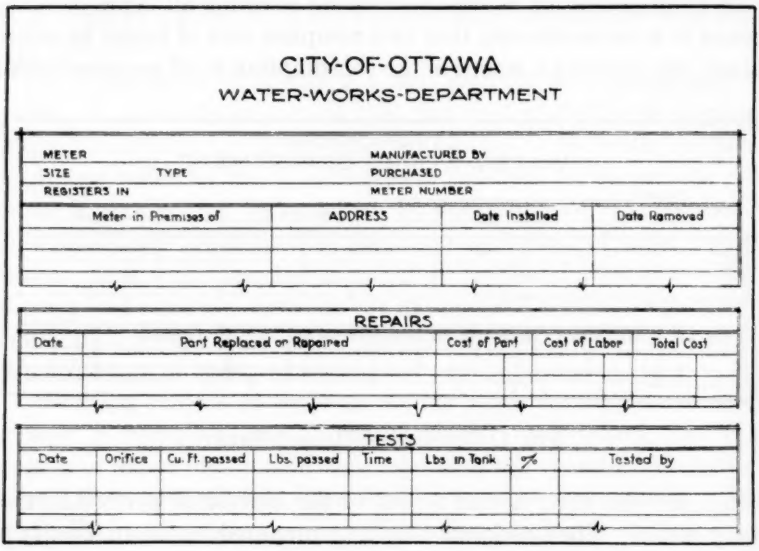
FIG. 1. CONSUMERS' RECORD SHEET

meter and the other a true record of the individual performance of every meter. The two forms of ledgers prepared for use in the city of Ottawa and which have worked out very efficiently contain the information shown in figures 1 and 2.

By the adoption of these two sets of ledgers with entries correctly made, it is possible for any member of the staff to prepare comparative charts on the actual performance of all meters in service and to determine successfully what it is costing the municipality for different makes of meters to register accurately each million gallons of water. In recording the consumption of water, both in meter readers copy and on permanent ledger, it is desirable to show each revolution of the meter, so that the figures are carried forward and, without any unnecessary searching of readings, the true history of the meter is at once apparent.

METER TESTS

It is not my intention to go into the details of the procedure to be adopted in the testing of meters, as you are all familiar with this practice, but in passing I should like to state that I consider the standard specification for cold water meters of the American Water Works Association, dealing with minimum flows, should be made very much more stringent than it now is, since it permits too great a variance on mean flows, while the present minimum flow is not sufficiently low to prove the sensitiveness of meters under test.



CITY-OF-OTTAWA
WATER-WORKS-DEPARTMENT

METER — MANUFACTURED BY
SIZE — TYPE — PURCHASED
REGISTERS IN — METER NUMBER

Meter in Premises of	ADDRESS	Date Installed	Date Removed

REPAIRS

Date	Part Replaced or Repaired	Cost of Part	Cost of Labor	Total Cost

TESTS

Date	Orifice	Cu. Ft. passed	Lbs. passed	Time	Lbs. in Tank	%	Tested by

FIG. 2. METER RECORDS SHEET

The following specification pertaining to the registration of small cold water meters has been adopted by the City of Ottawa.

Registration

The registration on the meter dial shall indicate the quantity required to be not less than 98 per cent, nor more than 101 per cent of the water actually passed through the meter; while it is being tested at rates of flow within the limits specified herein, under normal test flow limits. There shall be not less than 95 per cent of the actual flow recorded when a test is made at the rate of flow set forth under the minimum test flow.

SIZE	NORMAL TEST FLOW LIMITS	MINIMUM TEST FLOW	SIZE OF ORIFICE	PRESSURE
inches	*gallons per minute*	*cubic feet per minute*	*inch*	*pounds*
$\frac{5}{8}$	1– 20	0.033	$\frac{1}{32}$	78
$\frac{3}{4}$	2– 34	0.033	$\frac{1}{32}$	78
1	3– 53	0.1	$\frac{1}{16}$	78
$1\frac{1}{2}$	5–100	0.375	$\frac{1}{8}$	78
2	8–160	0.375	$\frac{1}{8}$	78

PERIODICAL INSPECTION

In regard to the periodical inspection of meters, it has been found by actual experiments that no definite term of years nor one complete cycle can be adopted, but rather the period of testing of small meters depends primarily on the make of meter and the quantity of water passed.

From actual observation information has been secured whereby tables for the various sizes of meters have been prepared which set

TABLE 1

MAKE OF METER	QUANTITY OF WATER PASSED
	cubic feet
Type A	60,000
Type B	75,000
Type C	125,000
Type D	150,000
Type E	200,000
Type F	200,000

The letters above refer to different makes of meters.

forth the different makes of meters and the maximum quantity of water which is registered before meters are returned to shop for official test and any necessary repairs. Table 1 was adopted for $\frac{5}{8}$-inch size.

These figures are subject to revision from time to time based on actual results obtained by changed conditions on different makes of meters.

WELL WATER RECESSIONS IN IOWA[1]

By James H. Lees[2]

Well waters of Iowa may be grouped into two classes, so far as their origin is concerned. These are waters derived from the glacial drift, with its interbedded sands and gravels, and those obtained from the underlying bed rock. The great body of the glacial drift consists of more or less pebbly compact clay which absorbs water rather slowly, holds but little and yields it grudgingly. Associated with the mass of this clay, or till, however, are bodies of sand and gravel, some of them more or less lenticular and of limited size, some of them with more uniform dimensions and of very considerable extent, either as widely distributed layers or as long narrow accumulations filling channels in glacial drift or in rock. Such bodies make excellent reservoirs and yield their stores of water readily enough, except in cases where the sand is very fine. Another type of material which is associated with the glacial till, although it is of eolian rather than strictly glacial origin, is the loess—a very fine-textured clay or silt, typically without sand or pebbles, although these are found locally, especially near the base of the loess deposit. Despite its fine grain and texture the loess is very porous and transmits water quite freely, hence it, and especially its sandy base, forms an aquifer of some importance.

FIVE DRIFT SHEETS

Five glacial drift sheets have been recognized in Iowa. The oldest of these, the Nebraskan, covered the entire state and apparently it still constitutes the major fraction of the glacial deposits of western Iowa at least. A basal sand seems to be widely present and supplies a number of wells which penetrate the overlying beds. A second drift sheet, the Kansan, covered all of Iowa except the northeast

[1] Presented before the Chicago Convention, June 9, 1927. By permission of the State Geologist.

[2] Assistant State Geologist, Iowa Geological Survey, Des Moines, Iowa.

corner and forms the surface drift of southern and northwestern Iowa. It is separated from the Nebraskan by a generally distributed gumbotil, a dark gray, very fine-textured gumbo clay which is residual from chemical weathering of the underlying till and which forms a floor for the basal sands which are related to the Kansan drift. A narrow strip of southeastern Iowa between Davenport and Fort Madison is covered by Illinoian drift, which resembles the older drifts in general character, in the presence of embedded and basal sands and in being overlain by gumbotil. Most of the northeast quarter of the state is covered by Iowan drift, which is notable for its exceptional thinness and for the great deposits of loess which mark its boundaries and spread in an ever-thinning blanket over the older drifts. Loess of approximately the same age is piled up also in thicknesses of thirty to a hundred feet or more along the bluffs of the two bordering rivers of the state and in lesser quantities along the Des Moines and over the intervening territory. In north-central Iowa, however, the Des Moines valley loess is mantled by the Wisconsin drift, the youngest of the glacial deposits of the state.

TOPOGRAPHY OF DRIFT AREAS

The topography of the northeast corner of Iowa, the only part of the state uninvaded by glaciers later than the Nebraskan, is exceedingly rugged, the drift is almost entirely eroded away and the only unindurated materials are alluvium and coarser filling in the valleys and residuum from rock wastage and loess on the uplands. The valley filling furnishes an abundant and permanent supply of water to wells sunk therein, but the upland covering is thin and over much of the area is well drained so that comparatively few wells find sufficient water in it, but are compelled to enter the underlying rocks. The thickness of the Kansan and Nebraskan drifts of southern Iowa is much greater than that of the northeast corner and reaches a maximum of 500 feet or more in some of the western counties. The topographic features are markedly erosional, although some upland tabular divides still indicate the level character of the original drift plain. Near the "breaks" water is likely to be found only at considerable depths and this is true of some parts of the uplands, as where no gravel beds have been penetrated and hence wells must be sunk through the entire thickness of the drift to search for the sand bed at its base. The deep, wide valleys of this province supply many

town and farm wells although even here some failures are to be noted and recourse must be had to ponded surface supplies. The characters of the Illinoian drift plain are similar to those of the province just described except that here are three drifts with their contained gravels and sands from which water may be drawn.

The loess overlying the three older drifts in southern and northwestern Iowa has always been utilized as a source of water for shallow wells, which have generally been sunk to the basal sand layer. In some parts of western Iowa a good many wells are supplied from a layer of gravel which lies immediately under the loess, but which seems to be residual from the wastage of the drift rather than depositional, as a part of the loess. The Iowan drift plain of northeast Iowa has typically a rather gently rolling surface, which, where the drift is thin, permits of fairly free natural drainage of the ground water. Where the thickness of the drift is greater, ranging up to 200 to 300 feet, the water content is much larger. The topography of the Wisconsin drift sheet is very immature so that except near the few larger streams the glacial materials are water-logged and the head of water is high, permitting the use of many shallow wells.

INTERMEDIATE WATER SUPPLIES

It is impossible of course to distinguish sharply between the waters of the glacial drift and those of the country rock, as there is naturally a continuous interchange, especially where the rock under the drift is limestone or sandstone. Not only are these rocks sufficiently porous to permit absorption of the overlying water, but wherever the solid strata are overlain by broken or residual materials these latter hold a supply of water and in many cases serve as a valuable aquifer. Where the country rock is shale, however, it acts as a confining rather than a contributing agent.

DISTRIBUTION OF STRATIFIED ROCKS

The stratified rocks come up to the glacial beds in a series of broad irregular belts with a general northwest-southeast trend. The series includes sandstones, shales, limestones and intergradations of these three types. There are no eruptive rocks to break the sedimentary succession and very little faulting and comparatively little warping have occurred to rupture or deform the beds. In age the strata range from Upper Cambrian to Upper Cretaceous, with the

older rocks exposed in the northeastern part of the state and the younger ones to the west, southwest and south. From their outcrops the strata have a general dip toward the southwest of about ten feet per mile, hence the older beds lie within reach of the drill over most of the state, exception being made of the northwest corner, where some of them are absent, and of the southwest, where search for them is hardly practicable. Exception should be made also of the disposition of the Upper Cretaceous beds in western Iowa, which instead of being arranged conformably with the older strata of that region lie upon the upturned eroded edges of these older beds. The entire series of sedimentary rocks rests on a substructure of quartzite, known in Iowa as the Sioux quartzite, which is practically impervious to water and hence marks the lowest limit of efforts to obtain supplies in wells. Its surface forms a great trough which rises above the newer strata in the northwest township of the state, is 1600 feet deep or more in the north-central counties and is 750 feet below the Mississippi in the northeast corner of Iowa. Wells in central Iowa do not reach it at 3000 feet.

WATER BEARING BEDS

The limestones, of course, are water-bearing and yield generously when a crevice or a channel is reached by the drill, but the most reliable aquifers are the great sandstones, including the Jordan, Dresbach and underlying sandstones of the Cambrian and the New Richmond and St. Peter of the Ordovician. These beds have a large area of outcrop in the adjoining parts of Iowa, Wisconsin, and Minnesota, they also have a very wide distribution under the younger rocks beyond the area of their outcrop and their physical characters are such as to enable them to carry enormous volumes of water under considerable head and under conditions of exceptional purity. These characteristics give the sandstones such high favor that over probably three-fourths of the state they are sought as the ultimate desiderata where deep-lying supplies are required. Flowing wells are obtained along the Mississippi as far south as Keokuk, but under the higher lands of the interior the head is insufficient in most cases to bring the water to the well curb. At New Albin in the northeast corner of the state the Jordan sandstone rises 966 feet above sea level while at Des Moines, the farthest southwest at which it has been reached, it is 1546 feet below sea level. The distance from the

Jordan to the New Richmond is about 175 feet while the St. Peter lies about 150 feet above the New Richmond. The Dresbach and underlying sandstones are at least 500 or 600 feet thick. The Jordan averages about 100 feet, the New Richmond 50 and the St. Peter nearly 100 feet in thickness, thus assuring an abundant water-containing volume.

The foregoing summary may serve to give a generalized impression of the ground water situation in Iowa and furnish the background for a study of the depletion of ground water resources. That there has been a depletion of these resources since settlement began is a matter beyond question—the difficulty lies in determining the causes and the amount, as well as the remedy.

McGEE'S STUDY OF WELLS

An investigation into the relations of wells and subsoil water was made in 1910 by W. J. McGee, a native of Iowa, who at that time was in charge of Soil Water Investigations for the U. S. Bureau of Soils. This investigation covered all of the United States, but only Iowa will be considered here.[3] Illinois, Indiana and Iowa were classed as having the most dependable records.

The 99 counties of Iowa were represented by 517 reporters, who sent information about 1527 wells, the highest number reported from any state except Missouri, which had the same number. Besides information about the locations and ownership of the wells the reporters were asked for data as to the character of wells, dates of making, and original and present depths of water in the wells. McGee divided the wells upon which reports were made into shallow or dug and deeper or drilled wells, excluding flowing wells and those of great depth. The summarized data for the two classes of wells were tabulated and arranged as in table 1.

GROUND WATER LEVELS

A number of the reporters remarked that the water level had not changed much in the preceding 20 years, that is since 1890. Some observed that there had been little change in 40 or 50 years, others that some springs and wells gave better supplies than formerly. But most observers reported that the general water level had lowered so much that, whereas the settlers and early residents had obtained

[3] United States Department of Agriculture, Bureau of Soils Bulletin, 92.

sufficient water from dug or bored wells 10 to 30 feet deep, now nearly all the wells within the reporters' knowledge were drilled—to depths of 60 to 100 feet, or some to 200 and 300 feet. In his own summary McGee states: "To one familiar with the state since the settlement of the eastern counties (as he was) the records and remarks jointly indicate a mean lowering of the subsoil water level during an average of 50 years that can hardly be put at less than 20 feet." However, as an average of the wells reported to him McGee estimated 12.5 feet as the lowering during the preceding half century. For the typical agricultural states McGee states that "the average lowering since settlement would appear to be no less than 9 feet, i.e., from well within to about the limit of capillary reach from the surface."

TABLE 1

McGee Classification of Wells

	SHALLOW		DEEP		AVERAGE
	Number		Number		
Date of making	768	1875	535	1895	1887
Depth of well, feet	895	36.1	632	153.0	
Original depth of water	749	15.4	506	77.8	
Present depth of water	852	11.8	551	74.4	
Rise	20	4.17	7	8.93	5.41
Fall	373	6.71	128	14.30	8.65
Depth to water table	895	24.1	607	78.7	46.1

CAUSES OF LOWERING

In discussing the causes of the lowering water table McGee dismissed a lessened rainfall as being negligible and unproved. Industrial causes such as tile and open ditch drainage, large wells, mining, etc., are of only local and rather superficial importance, as is consumption by animals and men. The greatest amount of lowering—amounting to 80 or 90 per cent—McGee assigns not so much to consumption of accumulated stocks as to the cutting off of the natural source of supply—the fact that under present conditions of cultivation storm waters do not enter the ground, but run off to the streams and so are unable to replenish the stores of ground water. The remedy, McGee points out, is to make each farm take care of all the water falling on it during the entire year by retaining this water by means of

mulch or well-tilled soil or contour furrows and ridges so that it will be forced to pass into the ground.

STUDIES BY UNITED STATES AND IOWA SURVEYS

For a number of years prior to 1910 the Iowa and United States Geological Surveys had coöperated in a special study of underground water conditions in this state and in the prosecution of this study every county in the state had been visited. While the collection of statistical data on the general ground water level was not the main object much information was gathered and in many of the reports on the various counties statements are made regarding the head of water. A few citations will tell the tale of changing conditions.[4]

The pioneer wells of a flowing field in Bremer county were sunk more than 30 years before and the head of a number has diminished. The static head of some wells on the hill slopes has been so drawn down that they have ceased to flow, but the supply is still ample on the bottom lands. On the open prairie of Buchanan county some of the early settlers obtained water by wells ending in pockets or streaks of gravel in the Kansan drift. Nearly all of these wells were abandoned long ago. In Cedar county the shallow wells, which at an early date found plenty of water at the base of the loess in ashen silts and basal sands, have been generally either abandoned or sunk deeper. Many of the older wells in Iowa county were dug or bored a short distance into the drift, but at present many drilled wells range in depth from 50 to more than 300 feet, ending in sand and gravel interbedded with or immediately below the drift. At Fairfield in Jefferson county shallow wells must now be bored 10 to 15 feet deeper than formerly. Ground water beneath the level prairies of Keokuk county stands high. The basal silts and sands of the loess yield sufficient for house use. Most of the water supply of Lee county is still drawn from the drift, but an increasing number of wells in recent years have been drilled to the water beds of the country rock. The Wisconsin drift of Cerro Gordo county is so imperfectly drained that where it occurs the ground-water table is near the surface. Elsewhere the Iowan drift is too thin and too well drained to be a reliable aquifer. The sandy base of the loess of Marshall county was formerly an important aquifer but drainage and cultivation have reduced the

[4] Iowa Geological Survey, vol. xxi; U. S. Geological Survey, W. S. Paper, 293.

ground-water level far below it. Wells in Adams county have been deepened to the sands at the base of the drift and the same is true of Cass county wells. In general less is said about lowered water levels in the area of the Wisconsin drift than in regions of older drift, more mature topography and better natural drainage, although even here a progressive lowering has been noted.

STUDY OF DEEP WELLS

Ever since the inception of its work the Iowa Geological Survey has made the study of underground water resources and conditions a major line of effort. Some of the results of this study of drift wells have been noted. The investigation of the deeper, artesian wells drawing water from the great rock aquifers is attended with less definite and satisfactory results. One can state in many cases that the head has declined, but the reasons are more obscure and one can not always assign changing conditions to stated causes. However, the facts may be stated even though definite conclusions can not be drawn.

In the northeastern counties, where the Ordovician and Cambrian sandstones lie not far beneath the surface, flowing wells are common in the deeper valleys. Many of these still flow, but the head of the Lansing well has fallen 15 feet and the yield has decreased from 700 to 300 gallons a minute. Many of the wells of this region have been allowed to flow unrestrainedly for years, virtually wasting the stores upon which they were continually drawing. A similar lowering of head was noted at McGregor. Dubuque has a number of deep wells, some of which reach the Jordan, some the underlying Dresbach and some still deeper sandstones. A number of these have suffered diminished flows, from all water-bearing horizons. In some cases the loss is attributed to deterioration of casings, in others to the local effects of nearby wells and in others to general lowering of static head, due to overdraft.

SOME CASES OF LOWERING

The Davenport artesian field has shown from the beginning a progressive loss of pressure, lowering of static level and diminution of discharge. This has been especially notable in the case of wells drawing chiefly from the St. Peter. The head of the Jordan and lower waters remains higher than that of the St. Peter and it is evident

that the latter bed is at least locally overtaxed. The head of the Witt's Bottling Works well has fallen from 81 feet above curb to 6 feet below curb and the yield from 300 to 20 gallons per minute.

Two of Cedar Rapids' city wells have been abandoned owing to the increased cost of pumping caused by the lowered static level and the well of the Burd Creamery Company at Council Bluffs has had the same history. The head of the Bloomfield city well has dropped from 130 to 172 feet below curb, although the yield remains the same. The head of the West Liberty city well has fallen from 9 feet above curb to 23 feet below, but the yield has increased from 120 to 250 gallons per minute. There have been no repairs. The head of one deep well at Washington has dropped from 44 to 133 feet below curb while the head of another rose from 100 to 70 feet below curb.

Dr. W. H. Norton, our underground water expert, has compiled a list of pairs of neighboring wells which shows their hydraulic gradient and the actual differences in head of water. With Doctor Norton's consent this list is incorporated in table 2.

A study of table 2 shows a number of incongruities. For instance, the hydraulic gradient between Green Island and Preston is about level, yet the head at the latter town is 24 feet lower than that at the former. Between Vinton and Garrison the gradient is level, but the head at Garrison is 38 feet above that at Vinton. The gradient from Sabula to Delmar is upward and the head at Delmar is 78 feet higher than at Sabula. The gradient from West Liberty to Oakdale sanatorium is upward, but the head is 27 feet lower at Oakdale. The gradient from Washington to Winfield is downward and the head at Winfield is 74 feet lower than at Washington. In all cases where the hydraulic gradient is normally downward the head is lower, but in cases where the gradient is normally level or upward the head seems to be independent of the gradient; in some cases it is higher, in others lower. These differences may originate in part in the different sources of the water in the contrasted wells. The elapsed time between the drilling of these pairs of wells ranges from 9 to 66 years.

These records as well as many others at hand seem to show that a variety of causes has been effective—some of them evidently conflicting. Deterioration of casing, local clogging of the water-bearing beds, interference of nearby wells, filling of the bore hole, leakage into the surrounding strata, these are some local causes which would tend to diminish the supply and lower the head. In some cases the

field is really being overtaxed, at least that portion of it near the wells. Whether the entire artesian field is being permanently overdrawn can not be told without intensive study of the relation between the supply and the demand.

RECENT INVESTIGATION OF GROUND WATER

When I was asked to prepare this paper I enlisted the coöperation of the United States Weather Bureau and the Weather and Crop Bureau of the Iowa Department of Agriculture in circularizing crop reporters and well drillers to obtain recent data on wells and ground water. Between 650 and 700 letters were sent out asking for information about the location of wells as to county, township and section; character, whether dug, bored, driven or drilled; whether in valley, hillside or upland; dates of making; depth; original and present depths to water and of water; and owners. The response to this inquiry is thus far by no means complete, but some general impressions may be formulated from the replies received to date. The effect of the rains of recent months has been to raise the water level in shallow—dug or bored—wells very markedly. On the other hand, a number of correspondents state that the deeper drilled wells are not notably affected by rainy or dry seasons. A number of men say that, whereas in early days, dirt wells, dug or bored, were sufficient, these later became unequal to the demands made on them and wells were deepened, either in unconsolidated materials or in many cases into rock. More recently dug wells are becoming scarcer and scarcer in some localities and reliance is being placed much more on drilled wells. Conversely, others state that there has been no appreciable change during their lifetimes. Some state that ponds and springs have disappeared, others that springs are as numerous as in former years. This may be due to recent rains or to especially favoring topographic and geologic conditions. Where a lowering of water level in wells is noticed it is variously attributed to tile and ditch drainage, in so far as shallow changes are concerned, to greater demands from a vastly increased amount of stock, to local causes such as clogging of the aquifer, overdrafts on individual wells or to the exhaustion of sand or gravel beds which had supplied wells. One driller states that since Nishnabotna river, in Pottawattamie county, was dredged and straightened the water level in wells has lowered 15 or 20 feet as much as 2 miles back from the stream.

TABLE 2

Data on deep wells

LOCATION	DATE OF COMPLETION	DIRECTION OF NEW WELL FROM OLD	DISTANCE	HYDRAULIC GRADIENT FROM OLD TO NEW*	ORIGINAL HEAD	FOOTING	RECESSION (−) OR ADVANCE (+) COMPARED WITH CONTROL WELL	NUMBER OF YEARS ELAPSED
			miles					
Green Island, C. M. & St. P. Ry.	1902				665	Prairie du Chien		
Preston, city well	1922	SSW	8	=	641	Jordan	−24	20
Sabula, city well	1895				652	Jordan or below		
Delmar, C. M. & St. P. Ry.	1917	SSW	22	+	730	Trempealeau	+78	22
Clinton, Water works	1886							
Nos. 1 and 3	1890				632	Franconia and Eau Claire		
DeWitt, city well	1923	W	18	+	617	Eau Claire	+15	33
Vinton, city well	1889				800	Prairie du Chien or Jordan		
Garrison, Canning Company well	1926	WSW	7	=	838	Prairie du Chien?	+38	37
Belle Plaine, city well	1907				776	Prairie du Chien		
Van Horne, C. M. & St. P. Ry.	1916	NE	12	=	783	St. Lawrence	+7	9
West Liberty, city well	1888				705	Trempealeau. St. Peter head, 676		
Oakdale, Sanatorium	1919	WNW	20	+	678	Shakopee	−27	31

Homestead, city well	1895				751	Dresbach?		
North English, city well	1921	SSW	20	−	719	Cambrian?	−32	26
Washington, city well	1891				694	Jordan		
Brighton, city well	1923	SW	11	=	658	Oneota	−36	32
Winfield, city well	1921	SE	19	−	620	Shakopee	−74	30
Keokuk, Hubinger well	Before 1889				667	Cambrian		
Donnellson, city well	1925	NNW	19	+	616	Shakopee	−51	36
Mount Pleasant, Hospital well	1862				689	Saint Peter		
Morning Sun, city well	1923	NE	19	=	623	Shakopee	−66	61
Somers, city well	1904				1097	Galena-Platteville		
Gowrie, city well	1926	SE	9	−	1058	Shakopee	−39	22

* + Hydraulic gradient normally upward from old well to new; = about level; − downward.

CONCLUSIONS

I believe that we are justified by the evidence at hand in drawing these conclusions: With regard to the shallow types of wells, dug or bored especially, in general these have become scarcer with the passing years because the supplies of water within their reach have gradually been depleted, partly by increased consumption by animals, by increased transpiration by cultivated crops, by open and closed drains, and partly by increased runoff of rainfall from cultivated areas. However, some parts of the state do not seem to have suffered from this lowering, perhaps because conditions are not so favorable for natural drainage and so the soil water is retained to a greater extent. Driven wells still find plentiful supplies because they are made as a rule in valleys with gravel strewn floors, which are less affected by changing conditions than are upland areas.

As to drilled wells, those of moderate depth as used on farms or smaller municipalities have gradually been deepened into the lower strata of the drift—many drillers speak of top water in yellow clay, and lower water in blue clay, with another horizon in sand at the base of the drift. In parts of the state having thinner drift drilled wells now enter the stratified rocks, some for a few feet, many for a greater distance. Most wells of this class range in depth between 100 and 200 feet, although some are as deep as 400 and 500 feet. Since these wells draw their supplies from the general body of ground water rather than from the shallower soil water fed by recently fallen rains, their gradual deepening in the wake of the constant lowering of head seems to point rather conclusively toward a real lessening of the amount of water in the ground, owing to both increased demand and decreased supply. In some localities this lowering of head amounts to 20 feet or more during the present century, according to the reports of several drillers, and the total lowering from the time of settlement must be much more than this amount. However, other drillers state that they see little or no difference in ground water conditions while they have been drilling and of course those local factors which affect shallow wells would have some, though less, influence on wells of this type. Again, while shallow wells fluctuate with the seasons and respond quickly to periodic variations in rainfall, deeper wells show much less change from season to season and year to year.

Finally, as to the deep artesian wells which seek out the great

aquifers of the stratified rock series, the evidence so far obtainable seems to be far from conclusive or even consistent. Some of these wells have suffered diminished yields and lowered heads, some of them headed lower from the start than did earlier wells in the same region. But some have higher heads than would be expected from the known factors and a few report higher heads or greater yields than formerly. Unfortunately for purposes of study these wells are not spaced closely enough for us to say definitely whether or not the general level or the amount of water has receded or remained the same, or, in other words, whether such changes as have occurred are due to local or to widespread causes. Of course, the deeper a well is the greater is the available radius from which it may draw its supply and the greater its chance of surviving drought or draft. Therefore, these deep wells as a class will always have a large assurance of permanence even in the face of the unfavorable factors.

AEROBIC SPORE-FORMING BACILLI WHICH FERMENT LACTOSE

By Stewart A. Koser[1] and Winifred C. Shinn[1]

The presence in water supplies of aerobic spore-bearing bacilli which ferment lactose has been reported several times. It is now recognized that these types may cause some confusion in interpreting results in the standard lactose broth, especially when examining treated waters. The confusion caused by anaerobic lactose fermenters, such as the Welch bacillus and its allies, has been well recognized for a considerable time, but the recognition of aerobic forms which may also give rise to misleading presumptive tests has been more recent.

From the reports which have appeared thus far it would seem that the aerobic forms are rather widely distributed throughout the country. Meyer (1918) found one of these types in the water supply of Newport, Kentucky upon several occasions. Ewing (1919) isolated from Baltimore drinking water an organism which he believed to be identical with that of Meyer. Other organisms apparently more or less similar were encountered by Perry and Monfort (1920–1921) in several Illinois waters, by Hinman and Levine (1922) in Iowa, by Lisk (1923) in a sample of milk from Florida and by Schreiner (1927) in chlorinated waters in Kansas. In addition, several others have noted their occurrence but did not describe the cultures. Thus, Havens and Dehler (1923) reported the finding of aerobic spore-bearing bacilli which fermented lactose in the intestinal tract of the top minnow in Alabama. Hall and Ellerson (1919) found them in California, Raab (1923) encountered them in the treated water at Minneapolis, though he states that they appeared rarely, and Ruchhoft (1926) has noted their presence in Lake Michigan water. In view of the practical importance of these forms Norton and Weight (1924) studied their distribution in the vicinity of Chicago. From 438 various sources 25 cultures were obtained. The highest proportion of positive findings was from animal manures, garden soil, and root and vegetable washings. Cultures were also obtained, though less frequently, from water supplies, dirt, street washings, and so forth.

The present observations are reported since they may add something to our knowledge of the distribution and occurrence of this group of bacilli as well as furnish a description of several types re-

[1] Department of Bacteriology, University of Illinois, Urbana, Ill.

cently encountered in Illinois. During the course of an examination of soil samples for members of the coli-aerogenes group (Koser, 1926) a number of these spore-forming lactose fermenters were found. The soil samples were taken at random from cultivated fields and pastures throughout the east central part of Illinois. In all, 52 samples of soil, mostly from cultivated fields, were examined both by enrichment cultures in lactose broth and by direct plating in Endo medium. Varying quantities of each sample were subjected to examination so that some idea of the relative abundance of the organisms could be obtained.

Aerobic spore-forming lactose fermenters were encountered in 23 of the 52 soil samples. From the 23 samples which showed their presence 64 cultures were isolated. The distribution of these forms in soil appeared to be rather irregular. In some instances 5 or 10 gram samples yielded negative results, while in others they were obtained from surprisingly small amounts, often from dilutions representing 0.01 or 0.001 gram of soil. In some places they are fairly abundant and it seems altogether reasonable that they may be washed into water supplies in fairly large numbers.

For purposes of comparison several other cultures of spore-forming lactose fermenters were obtained from other laboratories. These included 6 labelled B. macerans, 4 of which were described by Hinman and Levine (1922), one was from the type culture collection at the McCormick Institute and one from the University of Wisconsin. Also, one culture of those described by Norton and Weight (1924) was included and finally one labelled B. asterosporus from the type collection.

Study of the morphology, cultural and biochemical characteristics led to the conclusion that our own cultures fell into at least two distinct groups, with several minor variations. Of the entire 64 cultures, 57 appeared quite similar and for convenience have been referred to here as Group I. This group is significant from the water analysts' standpoint for they appeared to be rather common in soil and in some samples were undoubtedly present in rather large numbers. It seems certain that they would be washed into water supplies. The remaining seven cultures are apparently quite rare. All seven were obtained from one sample of soil and they were not encountered again. As will be pointed out later, there is some uncertainty whether these seven cultures should be classified as spore-formers. The description of the Group I cultures, which comprised the majority of those found, follows.

GROUP I

Microscopic appearance and staining. In twenty-four hour agar slants the rods are 2.0 to 4.0 microns long by 0.7 to 0.8 wide. In plain broth and in lactose broth the length was somewhat greater, usually from 5.0 to 8.0 microns. Gram stains were made from young agar slants and compared with known positive and negative controls. They were regarded as being Gram-positive. Several previous workers have placed these organisms or closely related types in the Gram-negative class, adding that the violet stain was removed with difficulty and that the interpretation might be easily confused. All cultures stained readily with the ordinary dyes. In some of the preparations a capsule-like halo could be seen. A tendency to granulation was noted, especially when grown in lactose broth.

Spores. In agar slant cultures these appear usually in two to four days. Considerable variation was noticed in the different cultures, some forming spores much sooner and in greater numbers than others. Spore formation was usually retarded in plain broth and in lactose broth. The spores are large, oval, much wider than the rod and their position in the rod varied from central to subterminal. They usually do not remain attached to the rod so that upon microscopic examination the free spores are usually seen.

Motility. This was observed in beef extract peptone broth, using cultures eighteen to twenty-four hours old. They were classed as motile. In all cultures some very active rods were seen while others in the same field exhibited little if any motility.

Colonies. On nutrient agar the colonies are small, 1.0 to 1.5 mm. in diameter, white, with somewhat irregular edges and a fairly smooth surface. When touched with the needle they show a tendency to adhere to the agar.

Endo medium. After twenty-four hours at 37°C., the colonies are small and deep red, about 1 to 1.5 mm. in diameter. They are considerably smaller than the average colon-group colony at this time. After thirty-six or forty-eight hours the colonies are slightly larger and the color is very deep red with a suggestion of metallic lustre in some cases. The surface is slightly raised and rather rough. In most cases the roughness took the form of fine irregular wrinkles, though in a few cultures it approached the concentric ring type. The margins are undulate or in a few cases very irregular approaching the ameboid type. The colonies are sticky and cling rather tenaciously to the surface of the medium when touched with the needle.

The most striking features of the colonies which would serve to separate them readily from Bact. coli or allied forms are the smaller size, the rough surface and their tenacious adherence to the medium.

Eosin-methylene blue plates. An interesting inhibition of growth occurred. After twenty-four hours colonies are either invisible or else barely discernible as minute pin-points. After several days incubation the colonies are slightly larger and appear as small dots, usually colorless. The inhibition of growth by this medium is quite striking and held true for all of our cultures of this type as well as for the other more or less similar spore-formers obtained from other laboratories.

Agar slants. On plain nutrient agar the growth is very scanty, filiform,

flat, dull white with usually a rather smooth surface and adheres somewhat to the medium though this stickiness is not nearly so pronounced here as on the Endo medium.

Nutrient broth. Growth appears first in young cultures as a diffuse turbidity, after forty-eight hours it is more or less flaky to granular, gradually settling to the bottom.

Lactose broth. Gas is apparent within twenty-four hours at both 30° and 37°. The amount in the inner tube varies from a small bubble to 25 per cent and after forty-eight hours is usually 25 to 50 per cent. There is a decided tendency here to formation of a flaky or stringy viscid growth rather than a diffuse turbidity. This characteristic appeared to be somewhat more pronounced at 30° than at 37°.

Litmus milk. An acid curd is formed within forty-eight hours, gas production is also evident with more or less distortion of the curd which is riddled with gas bubbles. In many cases this approached the stormy fermentation so characteristic of the Welch bacillus, though it varied considerably with different cultures and even with the same culture on repeated tests. This appearance was then followed by gradual peptonization or digestion of the curd. After a week or ten days the tubes are filled with a clear straw-colored fluid with some soft, partially digested curd in the bottom or clinging to the sides of the tube.

Gelatin. At 20° to 25°C. complete liquefaction occurred in almost every instance within six days. The Bacillus macerans cultures received from Iowa which were run for comparative purposes were negative at 6 days but showed some liquefaction after two weeks.

Fermentation and other biochemical tests. Acid and gas were produced from the following: Dextrose, levulose, galactose, lactose, sucrose, maltose, raffinose, arabinose, dextrin, inulin, salicin, mannite, and glycerol. In some cases gas production was delayed and appeared only after seven to fourteen days, though acid was evident after the first twenty-four to forty-eight hours. This was true especially of levulose, galactose, maltose, dextrin, inulin, salicin, and mannite. Negative results were secured with dulcite.

Formation of indole could not be detected by the Goré test in four day cultures in Witte peptone solution or casein digest medium. Nitrates were reduced to nitrites. Starch was digested. Hydrogen sulphide tests with lead acetate agar were negative.

Differential tests. The methyl red, Voges-Proskauer and citrate tests which have been recommended for differentiating members of the coli-aerogenes group were applied to these cultures, though it should be realized that these tests may have little significance when applied to a group of bacteria other than that for which they were originally designed. In the standard peptone-dextrose-dipotassium phosphate medium of Clark and Lubs the methyl red test was found to be negative while the Voges-Proskauer test was usually positive. A few cultures gave both negative methyl red and Voges-Proskauer tests. In the citrate medium (Koser, 1924) the cultures were unable to develop and the tubes remained clear in every case.

Anaerobic growth. Under the conditions secured with pyrogallol and NaOH in Wright tubes, these cultures developed readily on dextrose agar slants.

Control cultures of Bacillus cereus showed a scanty growth after forty-eight hours under similar conditions. In dextrose broth under vaseline seal development was as rapid as in open tubes. Gas formation was evidenced by the forcing up of the vaseline seal.

Heat resistance tests. Spore suspensions prepared from agar slant cultures survived ten-minute heating periods at 80°C. and at 90°C. After heating for five minutes in the Arnold (about 97° to 98°C.) negative results were obtained in some cases. Unheated control suspensions gave good growth in each case.

Brilliant green bile. Tests were made of the ability of the spore-forming lactose fermenters to develop in green bile media. A number of experimental green bile combinations were tried.[2] These were of the same composition as those used by Dunham and Schoenlein (1926) in their work with Bacterium coli. In addition to 1 per cent lactose and 1 per cent peptone the various lots contained 2 per cent oxgall with concentrations of brilliant green ranging from 1:15,000 to 1:100,000 and 5 per cent oxgall with concentrations of the dye ranging from 1:10,000 to 1:30,000. Controls with peptone, lactose and oxgall but without the brilliant green were also used.

Negative results were secured in every case, not only with our own cultures but with those received from other laboratories. The inhibition of growth was quite striking in comparison with control tubes of standard lactose broth and even though incubation was prolonged for a week or more,—a period far longer than that used in water examination,—no growth resulted. It is also noteworthy that there was no growth in the lots which lacked the brilliant green. Evidently inhibition is due to the oxgall rather than the dye.

OTHER LACTOSE FERMENTERS

In addition to the cultures described above a few others were encountered. As pointed out before, these were found but rarely and only 7 out of a total of 64 cultures fell into this lot. There is considerable doubt as to whether these 7 cultures should be classed as spore-formers and perhaps they should not be included in this report. They were all peculiar in that when stained with carbol fuchsin or other common dyes colorless oval areas could be seen in some of the rods and the appearance resembled somewhat that of a spore-forming culture. However, suspensions made from these cultures were not heat-resistant. Since resistance to higher temperatures is usually regarded as one of the fundamental properties of bacterial spores it would seem that these organisms should not be considered as spore-formers. However, they will be briefly described here since they represent a type of lactose fermenter distinct in some respects from the coli-aerogenes group.

[2] These experimental media were kindly supplied by H. G. Dunham of Digestive Ferments Company.

All seven cultures were quite similar. When taken from twenty-four hour agar slants the cells appear as short thick rods. They occur singly or occasionally in pairs. Capsules were frequently seen, especially in stains made from milk cultures. The oval colorless portion resembling a spore was rarely seen in cells from young agar slant cultures but was evident in cultures three or four days old. The "spores" appeared to be central or subterminal. The vegetative cells stained readily with the usual dyes while the Gram stain was clearly negative in all cases.

On Endo plates the appearance of the colonies varied somewhat with the temperature of incubation. At 30°C. colonies are large, circular, convex, quite viscid or sticky and of a deep pink or deep red color. They usually present a very watery appearance and adjoining colonies have a tendency to run together. At 37°C. the sticky viscid characteristics are lost and the colonies are then rather flat, butyrous and deep red. On eosin-methylene blue plates the growth was not restrained as in the case of the Group I cultures. Colonies developed as readily as on Endo plates and resembled rather closely the typical Bact. aerogenes colony.

An abundant white glistening filiform growth is formed on agar slants. After two or three days this becomes distinctly sticky and stringy. Older cultures gradually lose the watery mucoid characteristics. They become drier in appearance, finely wrinkled and at the same time a light yellow pigment appears. After two or three weeks the growth is wrinkled, yellow, rather tough and hard to separate from the agar slant. Upon continued cultivation on agar in the stock collection some of the cultures have shown a tendency to lose the extremely mucoid type of growth which they exhibited when first isolated.

In lactose broth fermentation with gas production appeared to take place more readily at 30° than at 37°. At the higher temperature growth was always apparent as a light turbidity after twenty-four hours, though gas production was not in evidence until forty-eight hours or occasionally longer. At 30° development was slightly more rapid and gas production was evident within twenty-four hours. The growth in lactose broth becomes more or less viscid or stringy. This was especially marked with some of the strains at 30° but not at 37° and the appearance of the mucoid stringy type of growth seemed to be dependent on the temperature of incubation.

Gelatin was completely liquefied in about six days. In litmus milk there was an acid reaction with ropiness. In some cases an acid curd was formed after four or five days incubation. No digestion of the curd was noted. Tests for indole in suitable media were negative. Hydrogen sulphide was not produced in lead acetate agar. Starch was not digested. Nitrates were reduced to nitrites. Acid and gas were produced from dextrose, levulose, galactose, lactose, sucrose, maltose, raffinose, and arabinose. Slow acid production without gas occured in dextrin, salicin, glycerol, and mannite. Inulin and dulcite gave negative results.

Methyl red tests were negative and the Voges-Proskauer reaction was positive. Growth occurred in the citrate medium. In respect to these differential tests these organisms were quite similar to Bacterium aerogenes. It is perhaps noteworthy that the colony on Endo or eosin methylene blue medium

was also quite similar to that of Bacterium aerogenes. Brilliant green bile failed to exert a restraining effect upon these organisms, as it did in the case of the Group I cultures. Upon inoculation into brilliant green bile gas formation occurred readily.

Heat resistance. Suspensions made from four to nine days old agar slants were subjected to various temperatures for different lengths of time with uniformly negative results. Even an exposure to 70°C. for ten minutes killed all cells. Bacillus cereus and several of the spore-formers of Group I which were run as controls survived moderate heating periods readily while these cultures were killed.

DISCUSSION

A review of the published reports of others together with a comparative study of the cultures received from Iowa, Chicago and other sources leads to the conclusion that the Group I cultures described here are quite similar to those reported previously by others. The culture received from Norton and the description by Norton and Weight (1924) both showed a very striking resemblance to our own cultures and it seems probable that they are the same. With the exception of a few minor differences our cultures also closely resembled the descriptions given by Meyer (1918) and by Ewing (1919).

A few points of distinction were noticed between our Group I cultures and those received from Iowa. The vegetative cells of our cultures were slightly shorter and heavier than the several Iowa cultures used for comparison. Also, our cultures liquefied gelatin much more speedily. On Endo medium the colonies were larger and, with a few exceptions, the edges not as irregular or lacerate on those of the Iowa cultures. In litmus milk the Iowa cultures produced acid but no curd, whereas our cultures produced a curd which was more or less torn due to gas production. Hinman and Levine believed their cultures to be identical or very similar to the Bacillus macerans of Schardinger (1904). Our cultures, while similar in some respects, could not be considered identical with the Iowa cultures.

The culture described by Lisk (1923) also resembles our Group I cultures, especially in regard to agar colonies and the deportment in litmus milk. On the other hand, there were several minor differences, such as the speed of gelatin liquefaction. Lisk considered her organism to be identical or very similar to the Bacillus asterosporus described by A. Meyer in 1897. The early description of this organism given by Migula (1900) and the later one by Bergey (1925) leave one in doubt as to whether or not it was a lactose fermenter. Chester

(1903), however, has given a description of a culture which was received from Kral's laboratory. He states that it fermented lactose with production of acid and gas and that milk was coagulated in about 10 days. Apparently the B. asterosporus of A. Meyer is fairly common in soil for it was noted by a number of the earlier German investigators. Bredemann (1908), especially, isolated it from soil samples collected in various parts of the world. He states that the organism grows readily in nitrogen-free media and has the power of nitrogen-fixation. The ridged appearance of the spores, said to be characteristic of B. asterosporus, was not noted in our study nor was it observed by Lisk. It is difficult to determine whether our Group I cultures should be classed as Bacillus asterosporus.

These various reports, taken in connection with our own work, indicate that at least several different species of aerobic spore-bearing bacilli capable of fermenting lactose have been encountered in this country. The different types appear to be more or less similar and they are evidently closely related. From the standpoint of the practical water analyst they may be considered as a group. Thus far, all the available evidence shows that they are not significant indicators of pollution and their chief importance resides in the fact that the fermentation of lactose which they produce may be confused with the presumptive test for the coli-aerogenes group. If the existence of such forms is clearly recognized by the water analyst it should be possible to guard against them, either by following through the confirmed procedure of the Standard Methods or perhaps by the use of special bile or dye combinations.

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BRILLIANT GREEN BILE FOR THE DETECTION OF THE COLON-AEROGENES GROUP

By Harry E. Jordan[1]

The previous work on this matter by members of this Committee was detailed in this Journal (vol. 4, no. 6).

The use of brilliant green bile has also been recorded by Howard, Ruchhoft and Lauter.[2] An article "Gas Production by Bacterial Synergism" by Holman and Meekison[3] has a decided bearing upon the errors to which the present standard methods are subject.

As was indicated in our previous communication, it appeared wise to study the use of brilliant green bile as an interpolated step in the present procedure to learn if such modified procedure might be found an improved substitute for the present confirmed test. Dunham and Levine studied the bile-brilliant green ratio and suggested that the co-workers use two materials:

1. A medium in which the inoculum would grow in a 5 per cent bile with a 1/20000 density of brilliant green.
2. A medium in which the inoculum would grow in a 2 per cent bile with a 1/75000 density of brilliant green.

The reaction of both media after sterilization was pH 7.1 to 7.4. They are hereafter referred to as 5 per cent bile and 2 per cent bile.

A group of co-workers agreed to submit certain samples passing through their laboratories to special procedure as outlined in a set of instruction sheets, the essential work outlined being as follows:

1. Colon group completion—according to 1925 Standard Methods.
2. Colon group completion according to 1925 Standard Methods—except

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[1] Filtration Engineer, Indianapolis Water Co., Indianapolis, Ind.

[2] Howard: Isolation of the colon group in water. Canadian Engineer, April 21, 1925. Ruchhoft: Comparative studies of standard methods and the brilliant green bile medium. Jour. A. W. W. Assoc., vol. 16, p. 778. Lauter: Earlier determination of Bacterium coli. Jour. A. W. W. Assoc., vol., 6, p. 625.

[3] Holman and Meekison: Gas production by bacterial synergism. Jour. Inf. Dis., vol. 39, p. 145.

5 per cent brilliant green bile is used for original planting instead of standard lactose broth.

3. Colon group completion according to 1925 Standard Methods, except 2 per cent brilliant green bile is used for original planting instead of standard lactose broth.
4. Colon group completion according to Standard Methods except that from tube of standard lactose broth—used as an original planting medium in which gas has occurred—a loopful of the active growth is to be transferred to a fermentation tube containing 5 per cent brilliant green bile—and completion carried on from this point according to Standard Methods.
5. Colon group completion as in (4) except that 2 per cent brilliant green bile is to be used instead of 5 per cent bile.

The following persons work has been summarized: Armstrong, Omaha; Berry, Columbus; Billings, Grand Rapids; Butterfield, Cincinnati; Howard and Thompson, Toronto; Kershaw and Taylor, Indianapolis; Lauter, Washington; Mahlie, Fort Worth; Marshall, Lansing; McCrady, Montreal; Nyhan and Gorman, Chicago; Raab, Minneapolis; Rider and Stroud, Tuscon; Stevenson and Herb, Sacramento and Wallace, Detroit.

In tabulating the results of the work, the basis of comparison used is the number of coli-aerogenes group completions found when the present standard method was used.

Along with this basic figure a notation has been made of the speed of gas production in completing cultures as shown by the per cent of the total number of cultures that formed gas in twenty-four hours. This has a bearing upon the problem of non-selectivity of the bile medium as shown on certain waters.

The data from all laboratories are summarized in table 1.

At this point it should be stated that there were 167 cases shown on the tabulation sheets where completion occurred in cultures handled on the bile which did not complete when standard methods were used. Several factors contributed to this. The major one was probably the element of random selection. Anyone who has handled a large number of biological growth operations is well aware that there is always the confusing element of variation in the growing power or characteristics of the individuals or groups selected for study. The element of chance has a decided bearing upon results such as are shown here.

On the other hand, the experience of Hale on the New York Metropolitan water supply is to the effect that the B. welchii type

organism will interfere with completion according to standard methods and not with material handled in bile media. This may be shown to affect at least part of the 167 non-standard completions.

Analyzing the data in table 1, we have the summation shown in table 2.

The purpose of this investigation has been stated as follows:

> For the purposes of this investigation it appeared necessary to submit a method that would give a density picture as near the standard procedure as could reasonably be attained, and at the same time clear up the confusion now existing on account of the wide divergence between original fermentations and complete colon group figures.
>
> The fundamental concept should be the need of finding every organism of this group that has any vestige of metabolic ability left at the moment of sampling, to reduce to a minimum the number of false indications, to reduce the amount of materials now wasted in standard procedure and to shorten, if possible, the interval between sampling and reasonable confirmation of the nature of the organism studied.

In the light of the above, the following facts are noted:

1. The 2 per cent bile is slightly superior to the 5 per cent both when used as the material in which to plant water samples direct as well as a subcultural medium. In both cases the relation between completions according to standard methods and the 2 per cent bile is higher than when the 5 per cent bile is used. The superiority is so slight as to leave the decision as to density subject to other considerations.

2. When the bile was used as a direct planting medium, the percentage of original fermentations completed checks with previous studies by this committee, but the 2 per cent bile shows a slightly higher degree of completion.

3. When the bile was used as a direct planting medium, no cultures were discarded because of the presence of spore forming organisms.

4. When the bile is used as a second step in a subcultural series, the degree of completion on the better bile density is 95 per cent (compared to Standard Completions). A study of table 1 will show that on a number of waters the correlation is perfect—notably in the large volume of work done by Butterfield. The greatest deviation is shown in the work by Miss Nyhan at Chicago and Mr. Taylor at Indianapolis. It is worthy of note that both these laboratories were working with a series of slow fermenting organisms. Mahlie at Fort Worth reports an abnormally slow fermentation rate, but correlates better than the two above noted.

TABLE 1

Summary—comparative tests of completion of coli-aerogenes group tests by various methods

	ARMSTRONG	BERRY	BILLINGS	BUTTERFIELD	HOWARD-THOMPSON	KERSHAW-TAYLOR	LAUTER	MAHLIE	MARSHALL	MC CRADY	NYHAN-GORMAN	RAAB	RIDER-STROUD	STEVENSON-HERB	WALLACE	
Standard lactose broth:																
Speed of gas production 24/48 hours ratio..	74	80	95	78	98	48	76	9	91	76	47	74	66	77	75	73%
Coli-aerogenes group complete.....	44	68	53	110	81	85	20	33	50	21	35	61	44	35	44	784
5 per cent brilliant green bile:																
Gas 24 hours.....	25	24	50	47	64	34	12	0	33	15	19	34	24	21	34	436
Gas 48 hours.....	30	54	51	56	67	60	18	21	44	19	28	44	34	31	41	598
Plate growth.....	29	54	50	56	66	60	15	21	43	18	28	43	33	31	41	588
Secondary broth—Gas.....	29	50	48	55	65	58	15	15	43	16	23	43	31	31	40	562
Non-spore-former, complete test.....	29	50	48	55	65	58	15	15	43	16	23	43	31	31	40	562
2 per cent brilliant green bile:																
Gas 24 hours.....	25	48	50	52	69	52	16	1	38	17	15	52	28	25	31	519
Gas 48 hours.....	31	64	54	64	70	76	19	22	44	20	32	59	36	31	41	663
Plate growth.....	31	63	49	63	70	76	18	22	42	20	32	59	36	31	41	653
Secondary broth—Gas.....	31	59	48	62	69	69	18	22	42	17	31	58	36	29	40	631
Non-spore former, complete test.....	31	59	48	62	69	69	18	22	42	17	31	58	36	29	40	631

5 per cent bile from 3 or 4:																
Gas 24 hours	38	60	54	108	80	67	20	17	44	17	27	55	42	33	44	706
Gas 48 hours	39	66	55	110	80	77	20	33	48	20	31	60	44	35	44	762
Plate growth	39	66	53	110	78	77	20	33	48	20	30	60	44	35	43	756
Secondary broth—gas	38	63	53	110	78	73	20	33	48	19	25	60	44	35	43	742
Non-spore-former, complete test	38	62	53	110	78	73	20	33	47	19	25	60	44	35	43	740
2 per cent bile from 3 or 4:																
Gas 24 hours	38	62	54	109	80	72	20	21	44	18	28	61	44	35	44	730
Gas 48 hours	39	63	56	110	80	78	20	33	49	19	31	61	44	35	44	762
Plate growth	39	63	53	110	79	78	20	32	49	19	31	61	44	35	44	757
Secondary broth—gas	39	63	53	110	79	74	20	32	49	18	25	61	44	34	44	745
Non-spore-former, complete test	39	63	53	100	79	74	20	32	48	18	25	61	44	34	44	744

TABLE 2

	TOTAL	LOSS FROM PRECEDING TOTAL	PER CENT	TOTAL COMPLETIONS	PER CENT
Coli-aerogenes group completion according to standard methods				784	100
Coli-aerogenes group completions when water was inoculated in to 5 per cent bile:					
24-hour gas formation	436		72.7		
48-hour gas formation	598		100		76.1
Plate growth (Endo or E.M.B.)	588	10	98.2		
Lactose broth re-fermented, complete test positive	562	26	93.7		
Spores not present or few	562	0	93.7	562	71.6
Coli-aerogenes group completions when water was inoculated into 2 per cent bile:					
24-hour gas formation	519		78.1		
48-hour gas formation	663		100		84.5
Plate growth (Endo or E.M.B.)	653	10	98.6		
Lactose broth re-fermented, complete test positive	631	22	95.2		
Spores not present or few	631	0	95.2	631	80.5
Coli-aerogenes group completion when original lactose broth fermentation is reinoculated into 5 per cent bile:					
24-hour gas formation	706		92.7		89.8
48-hour gas formation	762		100		97.2
Plate growth (endo or E.M.B.)	756	6	99.3		
Lactose broth re-fermented	742	20	97.5		
Spores not present or few	740	2	97.1	740	94.4
Coli-aerogenes completion when original lactose broth fermentation is reinoculated into 2 per cent bile:					
24-hour gas formation	730		95.8		93
48-hour gas formation	762		100		97.2
Plate growth (Endo or E.M.B.)	757	5	99.3		
Lactose broth re-fermented	745	12	97.7		
Spores not present or few	744	1	97.6	744	95

5. In three cases out of 1487 cultures, the presence of spores was noted by the worker and used as the basis of rejecting the completion. This is a frequency of 0.2 per cent and appears to be unimportant. The question of the interference seems to be answered in a practical manner.

The writer wishes to express his cordial appreciation of the work done by his associates in this project. This method of studying the merits of proposed changes in methods has demonstrated its efficiency. Appreciation is also expressed for the assistance of Dr. Dunham of the Digestive Ferments Company, who prepared and furnished free of charge all the special bile-brilliant green media used in the work.

Before suggesting final conclusions, it seems worth while to offer certain observations concerning present standard method procedure.

It will be remembered that in 1912, standard practice was modified to use a "bile" medium as the original inoculation medium. In 1917, it was modified to use lactose broth instead. Prior to 1912, dextrose broth was used. Both the earlier materials came to be recognized as imperfect. But at the present time, while a number of workers recognize the limitations of the present standard practice, there is a certain tendency on the part of others to overlook defects.

Putting the objections briefly, they are as follows:

1. The complexity of growth in lactose broth is often so great as to make the isolation of colon group organisms difficult.

2. Synergism is responsible for a very large number of cases in which gas is produced, but no plate growth follows. On water supplies where this occurs, the "presumptive" test is recognized as having little significance.

3. The diagnostic value of Endo or E.M.B. plate growth varies materially in waters of different degrees of pollution. It appears that in waters not freshly polluted where synergistic growths are frequent the picture that the plate affords is less useful than in freshly polluted waters.

4. Many laboratories appear to carry on completion subcultures from a plate on which the growth is massive and mixed rather than from a more sparsely planted plate on which the colonies are well separated and distinct.

These objections have a bearing upon the validity of this project. We have accepted the 784 completed tests as correct, and have required that the alternate methods approach or check with this

figure. Does anyone know that this is or is not a true picture? The answer must be that there are probably cases of synergism included in the 784 total, but that no definite statement can be made as to how great this error is. We must even extend our criticism in part to the brilliant green bile for there are 80 cases shown in table 2 when fermentation has occurred in brilliant green broth and plate growth occurred but there was a failure to obtain re-fermentation in lactose broth. There is that degree of non-specificity of the green bile broth which appears to permit combined growths to ferment, where the fermenting organism either died out in the broth before transplanting or was excluded by some selective action of the plate. So we must frankly admit that green bile fermentation is not limited to members of the colon group. It is worthy of note that, where fermentations are prompt, the group is present and where the fermentation rate is slow, other organisms complicate the reactions.

The study of brilliant green bile media has been carried on in many laboratories for from three to five years, in a few much longer. Many workers have adopted it in some fashion or other for use on waters in the process of purification or as an aid in rapid evaluation of finished waters. In the light of the studies with which the author has had contact, it seems fair to say that brilliant green bile offers a means of routine study that cannot be disregarded and should be written into standard methods in such a way that those who find it of value will use a procedure producing results comparable with those produced in other laboratories.

During the Chicago convention of the American Water Works Association conferences were held with Messrs. Norton, Levine, Hinman, Hale, Koser, Dunham, Langlier, Lauter, Howard, the writer and others present and, having knowledge of this study as well as others that have preceded it, the following procedure met the approval of most of the men present.

1. The Standard Method for Complete Colon Group determination should have emphasized the necessity of making Endo or E.M.B. plates with so dilute an inoculation that the colonies growing thereon are separate and distinct. The practice in many laboratories of making a heavy streak inoculation produces a growth that is of no value in the later steps of the completion process. If the microscopic examination for spores evidences a mixed culture, it should be replated and all data recorded should be from cultures as distinct as is possible to make them.

2. The group disapproves any tendency to evaluate a finished water by anything less than a "Complete" determination. In the case of raw waters or waters in process of purification the group approves a "Confirmed" test or even, in some cases a "Double Presumptive Test" if the use of such a method will result in more samples being examined and a more prompt judgement being reached as to the quality of the water and the efficiency of processes. In order to produce a consecutive picture of purification efficiencies it may be necessary to tabulate certain results on finished waters when they have given a presumptive or confirmed test. Such tabulation shall be considered as a comparison basis only and finished waters shall be carried to completion.

3. In cases where brilliant green lactose bile is used, it shall conform to the composition of Lot No. 15526 furnished by the Digestive Ferments Co. as follows:

	grams
Dried Oxgall	20
Peptone	10
Lactose	10
Brilliant Green	0.0133

For a water inoculum of 1 cc. or less or for loop inoculations the above dry material will be used in the proportion of 4 grams per 100 cc. media water and tubed in 10 cc. quantities. The reaction after sterilization shall be pH 7.1 to 7.4. The concentration of bile in the inoculated tube will then be 2 per cent and of brilliant green—1 part in 75,000. If for 10 cc. water samples, a total volume of water plus medium of 30 cc. is used, 6 grams of the dry mixture shall be used per 100 cc. media water with the same resultant density. If for 10 cc. inoculations the total volume of water and medium is 40 cc.—5.3 grams of the dry mixture is used per 100 cc. media water with the same resultant density. This concentration of bile and brilliant green is recommended because it shows a slightly higher degree of completion than the 5 per cent—1/20000 mixture and because the studies of Dunham and Levine show it to favor the maximum growth of the colon group. It is admitted to have a lower restraining power against organisms of the Welchii type, but affords sufficient protection in most water supplies studied.

4. The ordinary routine for waters in process of purification shall be the parallel planting of an equal quantity of water in an equal number of tubes of lactose broth and brilliant green lactose bile. If gas is produced in both in twenty-four hours the result may be recorded as "Partially Confirmed." If gas is produced in both in forty-eight hours the result may be recorded as "Double Presump-

tive." If gas is produced only in lactose broth the result may be recorded as "Presumptive."

5. If the technician desires, he may, having a "partially confirmed" or "double presumptive" test, transfer from the bile tube (which will contain a purer culture) to Endo or E.M.B. plate, and record the resulting growth as "Confirmed Coli" or "Confirmed Aerogenes."

If growth has occurred only in the lactose broth tube, transfer may be made to brilliant green bile tube and to Engo or E.M.B. plate. If the bile tube produces gas, the plate growth may be recorded as "Confirmed Coli" or "Confirmed Aerogenes." If the bile tube does not produce gas, the colon group is not present.

6. Samples which are to be carried to completion may be originally inoculated in parallel for purpose of process comparison. When both media ferment, subcultures shall be made from the bile tubes. If only the lactose broth tube produces gas, the subculture shall be made from it and carried as far toward completion as the reactions permit. In such cases the broth inoculation following plating shall be made both into brilliant green bile and into lactose broth and completion not be recorded if the brilliant green bile does not produce gas.

These suggestions are made in order that operators of purification plants may have methods of getting a fairly correct picture of the colon group presence or absence more promptly than is now possible. They are based upon work that has been carried on for several years in many parts of the country and it is the firm belief of all acquainted with the project that they will serve to improve laboratory conditions and result in water supply improvement. Few, if any, organisms of the colon group found by present methods will not also be found by the proposed methods and more samples can be studied.

REPORT OF THE TREASURER FOR THE CALENDAR YEAR 1926

I submit herewith my report as treasurer of the American Water Works Association for the calendar year 1926.

The funds of the association are on deposit with the United States Mortgage and Trust Company at their bank, 55 Cedar Street, New York City. This bank was selected in 1921 by vote of the Executive Committee.

RECEIPTS AND DISBURSEMENTS, JANUARY 1, THROUGH DECEMBER 31, 1926

Receipts

Balance on hand January 1, 1926	$4,301.31	
Received from Secretary	39,241.64	
Interest on deposits	84.48	
Interest on permanent investments	540.00	
Interest and profit on temporary bonds	164.44	
Sale of temporary bonds, less interest and profit	10,234.74	
Total		$54,566.61

Disbursements

Expended in payment of vouchers aggregating 379 in number, and comprising vouchers 2313 through 2692, both inclusive, except voucher 2315 which covered the check collection charges made by the bank in December, 1925	$52,874.18	
(Checks bearing the same numbers of the vouchers have been drawn, with the exception of those vouchers which cover charges made by the bank on check collections, and the amount of such vouchers is set forth below.)		
Exchange on checks as charged by the bank	15.88	
Deduction for four checks returned by the bank for various reasons	42.25	
Total		52,932.31
Balance, January 1, 1927		$1,634.30

In the above receipts there is included an item of $10,234.74 representing the purchase in March, 1926 of $10,000 of United States Treasury 4¼ per cent certificates, the amount as given including the interest up to the time of purchase. These certificates were purchased to increase the interest return on this amount, which for the time being could be taken from the current bank account. Later, as additional funds were required, the certificates were sold, the last certificates being sold in September, 1926. The net interest and profit resulting from the purchase of these certificates was $164.44.

Included in the disbursements is an item of $10,234.74, representing the purchase price of these Treasury certificates, including interest to the date of purchase. It is to be noted that the balance at the end of the year was $2667.01 less than at the beginning of the year. This was due to the cost of operating the association exceeding the receipts. During the year 1927 it is anticipated that the increased revenue from increase in dues and other sources, will prevent the expenditures exceeding the receipts.

COMPARISON OF TREASURER'S BALANCE WITH THE BANK BALANCE

Bank cash balance at close of business December 31, 1926, as shown by December statement, U. S. Mortgage & Trust Company	$1,993.41

Checks outstanding, December 31, 1926

Drawn in 1924:	*Drawn in 1926:*
No. 1448—$0.18	No. 2477— $1.74
No. 1512— 1.57	No. 2681—103.70
No. 1546— 3.96	No. 2684— 55.00
No. 1578— 1.74	No. 2685— 50.00
———	No. 2686— 2.05
$7.45	No. 2687— 2.05
	No. 2688— 0.84
Drawn in 1925:	No. 2689— 18.36
No. 2123—$2.38	No. 2692—115.54
	———
	$349.28
Total outstanding checks	359.11
Net bank balance, which coincides with the treasurer's balance	$1,634.30

Receipted vouchers have been returned to the secretary. The cancelled checks and duplicate deposit slips, with the account book

of the treasurer, have been submitted to the Auditor, and checked and returned by him.

The permanent fund was not changed during the year, and at the end of the year consisted of the following bonds, which were then in a safe deposit box at the United States Safe Deposit Company, 32 Liberty Street, New York City.

4—$1000 Dominion of Canada 5%	$4,000
1—$1000 U. S. Liberty 2d, 4¼%	1,000
2—$1000 U. S. Liberty 3d, 4¼%	2,000
2—$1000 U. S. Liberty 4th, 4¼%	2,000
3—$1000 U. S. Treasury 4¼%	3,000
Par value of permanent fund	$12,000
Interest on permanent fund	540

The above bonds were checked as to amount and attached coupons by the Auditor.

There has been a change made in the permanent fund since January 1, 1927, for the purpose of increasing the interest received, which will be set forth in the account of the treasurer covering the completion of the term of his office, which will occur at the end of the coming convention.

The treasurer received no salary, and is under $10,000 bond, which has been placed by the Finance Committee.

WILLIAM W. BRUSH,
Treasurer.

ANNUAL REPORT OF THE TREASURER OF THE ELECTROLYSIS FUND

May 31, 1927.

I submit herewith my report as Treasurer of the American Water Works Association, for the electrolysis fund, for the calendar year 1926.

The electrolysis fund is on deposit with the United States Mortgage and Trust Company at their bank located at 55 Cedar Street, New York City.

RECEIPTS AND DISBURSEMENTS, JANUARY 1, 1926, THROUGH DECEMBER 31, 1926

Receipts

Balance on hand January 1, 1926	$1,187.92	
Interest on deposits	21.68	
Total		$1,209.60

Disbursements

Payment to Albert F. Ganz, Inc. (Check No. 21)	$114.65	
Total		114.65
Balance, January 1, 1927		$1,094.95

This balance is the same as that shown by the bank notice in its December, 1926, statement.

WILLIAM W. BRUSH,
Treasurer.

SUPERINTENDENTS' QUESTION BOX SERIES[1]

TO WHAT ACCOUNT SHOULD CONSTRUCTION EQUIPMENT BE CHARGED?

STEPHEN H. TAYLOR (New Bedford, Mass.): We have two trenchers, a steam shovel, air compressors and a steam derrick. Any minor repairs that take place through the ordinary running are usually charged to the particular job on which the machine is working. For example, we bought this machine for an extension in laying a 40-inch pipe, and repairs were charged to that job. It has been working recently in some ditching work in connection with draining some of the swampy territory around the ponds. While that work is going on it is charged to that job, that is the ordinary small repairs. On any serious repairs, these equipments would be charged to account of tools, which account is included in our mains extension account.

We have no back fillers and air compressors are charged on our tools account, because that is going from one short job to another. Our trenching machines, of course, are not used on short jobs. The repairs are usually charged to jobs on which they are working, when it is finished up or broken down.

M. C. KINDER (Youngstown, Ohio): We have a plan for handling this particular item which I feel is rather complete, in so far as we have a department called "auxiliaries." Auxiliary equipment is one branch of that department or system of accounting. In our auxiliary department expense we have such operations as machinery, like the shop, garage, or automotive equipment and a division under the care and supervision of a general, all-round mechanic who is manager. This division is called construction equipment. In that department we have our two trenchers, air compressor, back fillers, tractors, trailers, our special pipe handling truck and our truck crane.

We considered for some time where to allocate the cost of maintenance and upkeep and how to distribute it equally among our vari-

[1]Presented before the Chicago Convention, June 6–10, 1927.

ous departments, which are main construction, maintenance and service construction.

Those three branches use our machinery. We have in addition a building construction division. We do all of our own contracting. Our expense or rather the life of our machines is estimated. We try to establish a rate based on the average life of such equipment.

We have an hourly rate for all of our machines, which this auxiliary department calls construction equipment and which we charge into main construction, service construction or maintenance. We are taking our compressor out on the road and charging one dollar and fifty cents an hour to that job, which money is actually transferred on the books into our auxiliary equipment department. The one dollar and fifty cents an hour price must absolutely support that machine. This department keeps its own costs. It has a system of cost and repairs in the operation of this machinery. This money goes back to the department and is placed to the credit of that machine at the end of five years, if it is correct to estimate the life of an air compressor at five years, a trenching machine at five, and a back filler at three. We attempt at the end of those periods to have money enough in those funds to replace the equipment. In that way we have continuously kept up an assortment of equipment, our additions to equipment being out of a surplus which we accumulate.

To determine this rate is quite a problem. We have been doing it now for three years and we found we made too little charge in our estimate. On the other hand, we felt that we should get two dollars and fifty cents an hour from one of our departments for the operation of our trenching machine, and later found that that was too much. Because of the amount of available time and the low cost of that particular unit over the first two years, we were going to have in our treasury, by the end of a five year period, enough money to buy three or four more machines.

We revised our rates downward. Every quarter we check up to get the rate per hour. We feel that at the end of those machines' useful lives we will have enough money in the fund to make replacements as well as keep those machines in wonderful condition. The expense of operating them is never charged to any one job. All departments pay the same for equipment and operation. Each department superintendent has to get his order in for construction equipment in his turn so that he will have a machine when he wants it.

MR. TAYLOR: To what is your first cost charged?

MR. KINDER: We set up a capital account. It all comes out of capital. We do not include picks and shovels. We just take major equipment. Our investment runs about $1000.

W. S. PATTON (Ashland, Ky.): I am very glad to have heard Mr. Kinder discuss the accounting method used on these items. Our own system in Ashland, Kentucky is not so good. It has been our practice at the close of each year to bring our equipment as nearly as possible up to perfect condition and to charge these replacements and unusual repairs into what we call an excavating account. We then apportion the amount charged into the excavating account among the different construction jobs on the machines that have been used. This method has proven fairly satisfactory, but by working out fairly accurate cost data it would have been easier to have charged rental on these different items direct to the job at the time the job was finished. The advantage of Mr. Kinder's method is that when the job is finished you know exactly how much is going to be charged to that job.

MR. KINDER: Perhaps some of the men here would be interested to know how many men we have handling this sort of thing. The question might have been raised in your minds as to the amount of detailed accounting necessary to handle the job in this way. At Youngstown we do all of our own construction work, all of our service installation, every bit of our building and small construction jobs, even to the repaving of streets. We have only one timekeeper, an accountant, and he has no trouble at all handling this detail of cost accounting. It really comes from the source on our daily time reports, which are turned in by the head of the department for these men. There is absolutely no excessive overhead or costs in keeping this system. It is convenient and has paid well for its time and trouble.

DAVID A. HEFFERNAN (Milton, Mass.): I am very much interested in this subject. Of course, it is something new to me. This year we have purchased an excavator. I was quite surprised at the difficulty in finding information in regard to the cost of operating the different makes of machines. Before purchasing our machine, which

is a gasoline machine, of 60 horse power, weighing about 17 tons, and in trying to get the information from the different cities using the machine, I found there were very few gasoline machines around the city of Providence and the nearby cities. They use steam machines and not gasoline.

We started on a job just before I came to Chicago and the nature of the soil was such that it required hard work to get through. The city of Quincy is noted for its granite and old granite teams or trucks that went by the streams and marshy lands would lose a bit of granite; a block would drop off the truck and break and would be thrown into the marsh. That condition has made the ground terrible to plow through and we took out blocks of granite $\frac{3}{4}$ ton in weight.

W. S. PATTON: Not with the trenching machine.

DAVID A. HEFFERNAN: Yes, with the trenching machine. We went through 2100 feet and took out blocks $\frac{3}{4}$ ton in weight, just nosed them right out. I saved a good deal of money by hand you might say. We do that on all the road work and I have saved $1500 on that job just by using that machine. There were granite blocks wedged in there so tight it was impossible to move them any other way than by using this machine.

W. S. PATTON: Is there anyone here using a different type machine and getting less depreciation?

DAVID A. HEFFERNAN: Our machine cost something like $8000 and we have a setup for a five-year term on that. I would like to get the daily operation expense. We figure using that machine one hundred and fifty days in the year with the water, sewer and street departments.

ALBERT R. DAVIS (Austin, Tex.): When we run into the glacier formation where we have boulders and nigger heads too large to handle, we use an excavator and clam shell. Sometimes these boulders run as high as three or four tons. We do not attempt to roll these out with the trenching machine or to blast them out. If we cannot dig a hole around them we hire our Universal drill a few hours and the boulder or nigger head is lifted out and rolled on to the truck and hauled off somewhere to a dump.

MR. KINDER: It has been our experience in work of that kind that the chain type trenching machine is not practical. Perhaps you could get one hundred and fifty working days from your machine, but we feel in Youngstown that it is hardly safe on a piece of trenching equipment to estimate over one hundred available working days per year. We base our rate on that number. We feel if our machines work one hundred days a year for five years they will have paid well for themselves. Of course, if there is any excess that is just clear profit and we can reduce our rates accordingly.

W. S. CRAMER (Lexington, Ky.): I might say to the men of the smaller towns who want to avail themselves of the trenching machines, that almost all of you have some contractor in the vicinity that has various types of trenching machines. If you will get in touch with him and give him the work of the smaller operations in the off periods you will be surprised how cheaply you can have that work done by contract. It is worth looking into.

MR. KINDER: The problem of picks, shovels and other small tools is rather difficult. We have felt that to equip tool boxes with the ordinary amount of tools for the job, making replacements by charging it to the job itself is a pretty good plan. If the tool is lost on a job, certainly the cost of that replacement, say of a shovel, pick, lantern or whatever it is, should be charged to that particular job. Those things do not all wear out at once, they are being continually replaced so that we can charge such equipment into miscellaneous cost of doing a certain job. Out storekeeper has a job in that. A man cannot requisition a dozen new picks and shovels and get away with it in our department. If he tries such a thing there is some question and we refer his requisition back to his supervisor. That supervisor certainly has more tools laid away in the tool room somewhere which are charged to his department.

We do not let a tool out on a job without a requisition. If a man wants as many as five lanterns he can requisition them from the storeroom. If he wants two dozen it is up to his supervisor or he may provide those from other jobs. We aim at all times to avoid a surplus of tools from the division. Just as many as they need and no more. Of course, they have some from the blacksmith's shop, but we try to charge that to replacement of lost and worn-out tools, not to the job.

W. S. PATTON: As I understand it, then, you start the construction of a water main on a certain street. We will say you have a supply of tools on hand to start with. Before the job is finished perhaps you may need five or six new shovels. Are new shovels charged to this particular job? In other words you are replacing the tools very gradually and the cost is absorbed by the job upon which they are used.

Our practice has been to charge these tools to our excavating account. Then we take the number of feet a trench has been dug by hand tools and apportion the cost of these tools into that account. It looks like small business, but it is nice to get it as accurate as we can.

W. S. CRAMER: We charge extensions for new work directly to the new account when they are purchased. Of course, our tools for tapping and those things are made up and are never used for excavation work. They appear in the records for tools.

W. S. PATTON: To what account is truck expense charged? Some trucks, of course, are used in construction work exclusively and others are used proabably in putting in service lines, setting meters, etc. What method is used in determining the proper charge for tires, repairs on your trucks and supplies.

W. S. CRAMER: We have an automobile account, which includes horses, carriages and automobiles. Horses are almost a back number, but we have a few at the pumping stations and to work in the woods.

All new cars, repairs and everything are charged into the automobile account. When we are laying a main or anything like that we charge a certain amount of money to that job as automobile rental, just as we do with out cartage. On a large main pipe job, we charge the driver's time to that job. Of course, the miscellaneous running around still remains in the automobile account. We charge only the larger jobs, such as pipe laying, etc., to that account.

MR. KING (Cleveland, Ohio): We charge a good deal to capital account. We have a great number of trucks and passenger cars. We carry the operation of these machines, trucks and so forth on the books against the maintenance and operation account. The operation is separate from the maintenance, and on our large construction

jobs, a certain rate, depending on the size of the truck, is charged against that particular job as rental. On the smaller jobs in that connection we charge it to the consumer. We have smaller trucks with a rental charge per hour against that particular job, so that the rental charge we get on all the trucks will very nearly offset the maintenance and operation of these trucks. On the passenger cars, of course, we do not attempt to allocate any of the expense to the job itself, as supervision is charged as a maintenance or operation item of automobiles. We have a certain amount each year, based on our previous expense, as to what our budget must cover the following year, so we get into the job on trucking a fair charge for the use of machines.

W. S. PATTON: I wonder if I understood Mr. King's explanation. I suppose you take each truck and charge all the gasoline, tires and repairs into one account. Say this is truck No. 1.

MR. KING: No, we do not charge to that particu ar truck. All the expense on the various trucks is charged into the truck expense account.

W. S. PATTON: Mr. King has figured out about what it would cost him to rent those different trucks per hour. The driver of the truck keeps a record of the number of hours of service given to each truck job. Suppose a truck runs down to the depot about two miles distant and picks up something and runs back to the pumping station. It only took about twenty-five minutes. What would you charge that to?

MR. KING: The man in charge of the trucking division does no work with any trucks unless he gets a requisition from the department wishing to use that truck. Of course, if there is a pick-up job or a half dozen pick-up jobs, about all one can do is charge an estimated amount, including the time going to the station, picking up things from two or three different plants, and allocate that time and charge on the requisition. But that does not apply as much to the construction end as to the operation of small pick-up jobs.

W. S. PATTON: I know of a plant not very far from Ashland that charges so much per mile. I believe they figured the cost of operating this truck to be ten cents a mile and each job is charged ten cents a

mile. If the cost runs more than ten cents per mile, the truck driver is called in to explain. If, at the end of the year, they find the truck has been operated for less than ten cents per mile there is some reward that goes to the truck driver, a box or a carton of cigarettes or something else. They use these operating costs or postings to stimulate the truck drivers toward extra effort in lowering costs.

MR. KING: All of our machines are classified. There has been a division started to take care of and find the actual cost for operation and maintenance of each machine. Numbers are put on each truck and on the passenger cars, instead of putting on speedometers, and a daily record of the gas and oil and everything that goes into that particular truck or passenger car is kept, so that within probably a year's time we shall have valuable data as to what the operation and maintenance of those cars are.

STEPHEN H. TAYLOR: I think we are splitting hairs when we try to make the division other than between capital account and operation. The little question of distributing these items should not be taken seriously. I do not believe anyone here does take it seriously. For instance, we had a question come up not long ago on a tapping crew out on a tap. The question arose as to whether to make a distinction when the water had to be turned off and on and an emergency turn-on, one that is not taken care of in the usual way. We decided that those things could not be divided. It is trying to split hairs when we try to divide them. It is purely a give and take proposition. Suppose we have a break or a hydrant knocked off. We can locate a tapping crew while our extension or maintenance crew is probably some distance away and we do not want to disturb them. We make no record whatever for taking that tapping crew on account of the broken hydrant.

TAXATION OF WATER WORKS PROPERTIES OUTSIDE OF CITY LIMITS

STEPHEN H. TAYLOR (New Bedford, Mass.): The Massachusetts law is very strict in this regard. The water taken for water supply in other towns is not taxed, but in lieu of taxation they pay at the regular tax rate on a valuation which is arrived at by taking the average of the valuation of that property for the three years preceding the time when the city took it. That value was fixed for all time and the rate fluctuates with the tax rate in the town.

For instance, in our pumping station we do not pay a special tax. We pay in lieu of that a tax on the property on which the station is located. In other words, the town gets just about the same revenue from the land which the city takes as it did before we took it for water works property. There is no increase on account of improvements or decrease on account of cutting off work or anything like that.

MR. BRIGHT (New York, N. Y.): I simply wanted to say we have to pay taxes on our property. The tax is not on the previous rate of the land, but it makes it convenient for equipment rates on the property. It is a much higher rate than the previous rate on any particular parts of the land.

W. S. PATTON: Mr. Taylor, how does the assessment compare with the investment cost of the pumping station you speak of?

S. H. TAYLOR: In the tax assessment?

W. S. PATTON: Yes.

MR. TAYLOR: I should say we bought most of that property on a very low rate because it was not known at the time that it was to be taken for water works purposes. It was supposed to have been bought for pleasure resorts.

It seems to me the valuation placed by the town in most cases is rather less, as few cities and towns expect to tax property at full

value until they find it is being taxed that way. There are one or two exceptional cases that are taxed for a higher rate than when purchased, but in the long run I should say the valuations are below the price paid by the city.

W. S. CRAMER (Lexington, Ky.): Mr. Taylor says they are taxed only on the land. Is there any person here whose city is taxed for the water mains or taxed for the pumping plant, pipe line, or other service, lying in the county outside of the city?

W. S. PATTON: Mr. Cramer, are your water mains outside of the city taxed as well as your pumping station properties?

W. S. CRAMER: In our case we are charged for water mains and pumping station besides the tax on the land itself.

C. F. DRAKE (Pittsburgh, Pa.): We are not taxed for our water mains, but we are taxed for the reservoir and properties. We have a concrete reservoir outside of the city.

ONE OR TWO MAINS ON WIDE STREETS

E. F. DUGGER (Newport News, Va.): We have adopted the double main procedure in practically all of our main business and residential sections. We have there a possible advantage over some of the other communities. Our township was laid out by one individual who owned the whole community. Our streets are of uniform size, our blocks are of uniform size. Of course, the avenues and all streets are the same width. We have a parking strip between the curb and sidewalk. About two or three years ago quite an extensive paving program was instituted in our city. Practically all the streets were paved at that time. We adopted the method of installing a small main on the opposite side of our street where we had renewed the service for this paving work.

We have not been governed so much by width. We have found our saving has amounted to quite an item in this work. We have a very well graded system and we tie our 2-inch main in, for instance, on a 550-foot main block where we have a large size main on the street. Our main will be on the south side of the street and on the north side a two inch main will be run and tied to each end of the large main. We can then cut off either side of this section and still give water for the whole business section. In that way we have avoided all of the long services and we have cut down the cost of our renewals. We can put in also a swing joint for our service connection.

I do not believe this is feasible in all cities, but, since we have no paving to break up, we have an economical procedure.

W. S. PATTON: Are they cross connected?

E. F. DUGGER: They are at the end of each block, every 550 feet I should say, and are tied on a well graded system.

W. S. CRAMER: Mr. Dugger, were your original mains so located that in paving the street you did not have to re-lay them?

E. F. DUGGER: We have an established grade. In Virginia there is not much frost. If we are down two feet, we are absolutely

safe. We never go on a street until the city says so. At this time it was under private ownership and we never laid a main until we had instructions from the city engineer. Our grades have never been broken and with probably two exceptions we have never had to re-lay a main on account of that.

W. S. CRAMER: A great many people have adopted the practice of putting in a 4-inch line. We have gotten into trouble doing that, so we have adopted the use of the 2-inch cast iron main for the outside and we are getting very good results from it. While we are not getting the circulation, the use of the water on the line helps the condition over the one we had in the 4-inch.

MR. KINDER: May I ask the gentleman what the widths of the streets are, that is, the minimum width?

W. S. CRAMER: A uniform width of 60 feet between curbs. That is what we have on all our streets, and 80 feet between property lines.

MR. KINDER: How much paving do you have?

W. S. CRAMER: These streets to which I refer are paved the full width. If they are not we do not bother with double service.

W. S. PATTON: If it is 80 feet to the property line, of course, you have room in there for sidewalks on each side? In the natural paving of your streets, probably where you are using those dual mains, the street is not paved more than 30 to 35 feet perhaps. Is not that about right?

MR. DUGGER: I think I did use the word parking strip. Our sidewalks do not come all the way. We have a space for trees, not the parking strip itself. Our streets are paved solid from curb to curb.

W. S. PATTON: What is the general width of the paving?

E. F. DUGGER: Fifteen feet from the curbing line.

MR. KINDER: At Youngstown we do not make any attempt to use double mains. Our streets average 50 feet. Where we do run into a

wide street, we believe there is a balance of economy which may be effected by the dual system. We charge uniformly for our service, installing them all ourselves. We charge each side or each lot a uniform price regardless of the size of street. We do not double main unless by so doing we can salvage enough or save enough on our service to pay that cost.

In our town the consumer pays for his service from the main. If a 50-foot street has a certain price, on which we have found we can come out even or where we can justify the investment in the second main, in lieu of excessive cost of service, we do it.

Another thing entering into that which is quite a factor is the grade of development in the particular section. We do not attempt to double main unless we feel certain the street is going to build up quickly and we will get back our investment in the second main very quickly from the excess cost we have charged to the consumer for his service.

MR. PATTON: I would like to ask Mr. Kinder what size he generally uses for the secondary main?

MR. KINDER: We have never considered anything smaller than 4 inches.

MR. PATTON: Mr. Cramer stated that 4 inches had been giving him trouble. I would like to ask Mr. Cramer what trouble he has experienced from using the 4-inch main.

MR. CRAMER: Lack of circulation. I cannot explain it except to say it is there.

MR. PATTON: The water has a strange taste.

MR. CRAMER: Yes.

MR. PATTON: About how far apart are the cross connections?

MR. CRAMER: The distance of the average city block.

FRANK A. LYON (Oneonta, N. Y.): The gentleman over here has hit upon a question that is practically the same condition that we

have in our work. There is an 18-inch main running from our reservoir to our filter plant. There is also a 10-inch main and we find by the tests made from the operating end of the plant that we get practically no water unless we exceed 2,000,000 gallons. They are both at the same elevation in the reservoir and we cannot determine why our 10-inch main does not feed the same as our 18-inch.

MR. CRAMER: We have two or three sections in our city streets feeding right around our 4-inch mains and we have a great deal of trouble with red water. Of course, our city is troubled with red water a great deal and that is one of our problems. We have practically overcome it with the 4-inch mains, but we have never determined all of these matters to our entire satisfaction.

JAMES SHEAHAN (Memphis, Tenn.): We have some 4-inch lines and we are taking care of the future growth of the city. We have some streets in Memphis as wide as 60 feet. In some sections we are putting in a main on each side of the street, but where we have a street 50 or 60 feet wide we tap across with one branch in the middle of the block, or we make a practice of going every 100 feet, according to the amount of water that is to be used on the opposite side. We run on the sidewalk and put a stop in there and extend our lines so that we get circulation enough to keep the water moving all the time.

When there is circulation in the 4-inch line, the 8-inch line can take care of all the supply. If you will carry your line across the street and make your connection on the side according to the size of the houses or stores you serve, you will get rid of all that trouble.

We are going into all our subdivisions and figuring out the needs according to their size, putting in a 6-inch line for a distance of 1000 or 1500 feet. We put a header in the other way, large enough to supply the street beyond that. We have a project on hand for next year. They have annexed a part of the city, about 30,000 people at the edge of the town and we have that part all laid out. Our header mains are big enough to take care of anything in there, but we will not use less than a 6-inch main. On our wide streets we will place one large main and use these little connections across to the other side and not have over 4-inch on the opposite side. Then we will have circulation all the time. We do not put the connections on the opposite side, unless there is a house close to them, but we keep our mains alive.

If you build a house on the opposite side of the street and if the street is wide we will put a connection over there when you need it, but not before. We will not put anything in to be left as a dead main, because the water gets bad when it does not circulate. When they do not use it any more we cut it off. When a tenant moves out of a rented house we cut off the supply.

MR. PATTON: What sort of pipe do you use?

MR. SHEAHAN: Lead connection. Our pressure in some places, where there are so many houses, makes the water a little muddy and we are going to galvanize soon. Our city at the present time has one of the lowest rates in the South. We are in the number two rating and we have gotten it on account of the way we are laying out the lines. We reduced two years ago from a fourth rate to number two. In the beginning just a few 4-inch lines were laid, but we are taking them all out.

MR. LYON: I would like to ask the gentleman if he is troubled with red water?

MR. SHEAHAN: No, we have well water. If you will aerate red water you will get rid of it all and you will not have any trouble doing it. We have the same condition in Memphis. There is CO_2 gas in the water. It turns red in the mains and, when you boil it, it comes up to the surface. It will always show up under pressure. Cold water does not give so much trouble under pressure and will not be noticed to such an extent, but as it is heated it rises. We have practically eliminated red water. We use from $\frac{1}{2}$ to $\frac{3}{4}$ grain of soda ash per million gallons of water and that increases our CO_2 up to 7.5, or about 7.8. What you want to do is get the CO_2 out of it.

MR. LYON: That is our difficulty. The alkalinity is so low in the water we have to increase it in order to overcome the red water.

MR. SHEAHAN: I will give you our experience in Memphis with red water. Anyone who uses artesian water knows red water is connected with it. We put in our pumping station. We had been using three different kinds of pumping systems. The last time we put one in we had some exhaustive tests made to determine what kind of pumping

system we should use, and after testing the matter out we found that the air lift took out about 70 per cent of the gas that caused the red water. We have a filtration and aeration system which take it all out.

We have some curious streets. There are so many different widths and conditions it is hard to tell exactly what size street we do use. We take not only a wide street, but a paved street, asphalt, concrete, of any kind and do the same thing. We put our mains in the grass plots, if we have them, and if not we put them on the side streets. We have many conditions where the old fashioned equipment is used. At one time we put them down in the middle of the street, then the street cars came along and camped on top of them and we were everlastingly repairing the mains. Now we do not put anything in the middle of the street. If we have a grass plot, we go on the side, then we lay these lead pipes for one side of the street and whenever there is a house built there we give the connection. We do not dig up the street at all.

MR. CRAMER: The reason we use 4-inch is because we prided ourselves on the fact that we had nothing but cast iron and lead in the entire system. We did not want to use any other material for piping those lines, until seven or eight years ago when they brought out the smaller sizes of cast iron pipe, we saw the advantage. Since then we have used those smaller sizes of cast iron pipe. Some of the smaller jobs we are taking care of with $1\frac{1}{4}$ inch cast iron pipe. We had to use that kind. There was nothing else available except lead. As this was costly and rather hard to handle we just used the 4-inch cast iron lines.

LAYING SERVICE PIPES IN ADVANCE OF PAVING

MR. KINDER: I feel there are certain conditions surrounding this practice which should temper one's judgment. It depends a great deal upon the rate of development of the section being paved. It is absolutely uneconomical, although we do it in Youngstown. Youngstown is a rapidly growing city. As soon as a paved street is down, one might say that fully a 100 per cent built up condition is reached within three or four years. Therefore, we feel that it is absolutely the thing to do, rather than make the duplicate investment in additional mains or dig up paved streets. In a community which is not well paved, conditions would be different. If you were paving a main highway out through a district which is probably not to be built up, but is merely to be used for through traffic, perhaps the service lines in advance of paving is not justified.

MR. CRAMER: We thought the same thing, but experience has taught us otherwise. I can now think of two instances, one particularly of a large hotel built in what was once a residential section and is being tied into the business district. Fifteen years ago we put five taps on that piece of property. This particular property was a small one and had developed into a center for automobile accessories and things of that sort, all owned by one man, and one supply was taking care of all the stores. This hotel was built and they took a 4-inch connection. We have on that property five connections which in the natural order of things would have been used, but the original plan has been abandoned and the other four taps have not been picked up.

We have several instances of just that kind and we have come to the conclusion that it is not worth while. You do not know what the development or what the size of the connections will be. When it comes to the residential sections it is almost useless, because one lot line changes the whole situation. We have added as many as three taps on one lot and no taps on the corresponding lots. You can never get them right. They are a continual source of expense and a bugaboo of tearing up the pavement even on the five-year limitation. There is simply nothing to it in this day of modern repairs.

FRED B. NELSON (Highbridge, N. Y.): In New York City we have had extreme trouble in locating leaks from old abandoned service pipes. We thought we would be very much averse to putting anything in the ground that we did not know definitely would be used immediately. As some of you probably know, an abandoned service pipe, especially in a congested location like New York City, is very apt to cause serious trouble in locating when it leaks. Due to the fact that there is no vibration set up, since it is too far from the main to set up any, we have frequently in New York City had to put down sounding holes in many places in the street off the line in order to locate the leaking end of those old abandoned service pipes. They were not put in with the idea of reaching any future development. They were simply abandoned where they became too small to serve the purpose.

I think our trouble in locating leaks that develop in these old mains, which were put in and never served the purpose for which they were intended, when the development comes along, justifies doing away with that practice.

MR. KING: Our general practice is and has been for a long time to put in our service connection in advance of paving, because as the gentleman from Youngstown said, development is very rapid in new streets that are laid out. In case we find the connections are not large enough, I do not know whether it is the practice to plug the old ones at the main or not, but we do that where other connections are put in or larger ones are used, and charge the expense against the property.

STEPHEN H. TAYLOR: One point that has not been brought out and which is probably practiced by all of you, is that in advance of street paving everybody should be notified by the city authorities that the street is to be paved and cannot be broken up again within five years. Unless the owner shows an interest, at least enough to make his application and tell us where he wants his service and what size he wants, there is no use bothering with it. We have had the experience of putting in the service and it would not be the right size or in the right place. In many cases it is never used, so there is not much difficulty after all in replacing the pavement if you go at it properly.

On the short side of the street we cut only one opening, tunneling

the rest of the way. On the long side we make two openings and tunnel the rest of the way. We pass on to the owner of the property the cost of surfacing that street.

We have found that it is not really worth while to put in pipes in advance of paving.

DAVID A. HEFFERNAN: They are putting in force in Milton today something which I do not approve, in regard to sewers, gas and water.

On a new construction a permit is granted by the engineering department of the different utilities and the location is granted for the sewer, we will say. The sewer is put in first and then the water is put in on a table or a bench on one side of the sewer. The gas is put in on the opposite side. There is only one opening. I am strictly opposed to this layout, but I did not have strength enough to stop it from going through.

Several years ago this very same question came up in The Association. It was thoroughly discussed and the consensus of opinion was that it was poor policy, but we now have in the town a new engineering department that started last year so this layout has been approved. In some conditions it can be worked out all right. I believe it is all right where there is a ledge when you sewer the street to save the consumer the cost of putting in the several trenches and the cost of excavating.

The gas pipe does not go very deep, about 18 inches or 2 feet, but the sewer goes down the depth of 5 or 6 feet. In making the excavation in loose or soft material it is almost impossible to put the water trench in and you are bound to get settling from that sewer trench. The idea is to reduce the cost of paving and not to spoil the street in taking up the different connections.

W. A. HUTCHINS (Freeport, Ill.): We followed the practice that Mr. Cramer has outlined in our town. We do not construct this service in advance of the paving for the reasons stated before. The development has grown so fast following the paving that within two years we have probably the entire street ripped up. I was wondering what they did in Mr. Cramer's town, for instance, with the sewers. Are the house connections omitted in advance of paving. There is no argument for putting in the sewer studs and none for the gas service. For every lot that means three separate excavations. Our sewer studs as a rule are put in by contract and that means a separate

trench for the sewers and a separate rate of contracts for the water service.

This year, and in fact a considerable part of last year, the water department constructed the sewers in connection with our work. We constructed them in the same trench as a rule by putting the water service on the side and we have been getting along pretty well.

As far as the service not being properly located when the street is developed, we think we have overcome that. In fact we have never had any trouble in that respect. There have been a few cases where a building much larger than was anticipated is being constructed on several lots where you probably did bury three or four or five service lines that were never used. But that was the exception rather than the rule. In the residence properties we believe we waste less than one per cent of the services we put in.

We have an ordinance that provides for a certain development and we place these studs to fit into that development. People always take advantage of the most intensive development that it is possible to make along the street after it is paved. We would never think of leaving out service in advance of paving.

MR. CRAMER: I was speaking of the older residential districts which are developing into business districts. In the newer districts with your parking space on the narrow streets, we are putting the pipe in the parkway. On the wider streets we are using a wider line. We do not pay any attention to the tapping. When we have a main in the parkway we use a pipe pusher and do not disturb the street at all. We have quite a system of national and state highways entering Lexington. Our mains there are laid on the side of the highways clear of the improvements. We use the pusher on the off side in all cases and we do not disturb the street or highway in any of those sections.

MR. PASTER: Do you use iron, brass or lead pipe with the pipe pusher?

MR. CRAMER: We use the lead pipe.

FLUSHING MAINS

CHAIRMAN PATTON: On calling for a show of hands, I find that we are about evenly divided on whether to flush during the day or during the night.

MR. LYON: We do not flush during the day except on the main street.

MR. NELSON: In most cases we do our flushing in the daytime.

CHAIRMAN PATTON: Do you isolate the mains being flushed? I will ask you to hold up your hands if you are in the habit of isolating the mains when they are being flushed. That is to flush one main with the side lines cut off so that you can flush straight through. Those who do this please hold up your hands.

(Seven hands.)

CHAIRMAN PATTON: Evidently the rest of you do not.

MR. CRAMER: I would imagine most of the flushing is done on dead ends. The only time that we use the shutoff system is in the spring and fall when we have a general draining of the smaller mains. Most of our flushing in the summer is confined to the dead ends. Lexington is laid out with the turnpikes running into the city much like the spokes of a wheel and, of course, we have a lot of dead ends. It is almost impossible to tie them in and those are the ones that get the most attention. Occasionally we have a bad condition and then it is necessary to shut off to clean a small main where the circulation is not good.

CHAIRMAN PATTON: In Ashland we find it an advantage to flush the mains four times a year. We flush the entire town. We do not take the time or the trouble to isolate any mains. We start at the upper end of the town in the business section. We isolate one section so as not to get the water muddy or disturb any other mains. We

will go down through the business section and get that flushed at night. The next night we take another section and so on until they are all flushed. Water is always improved after the mains have been flushed.

I was surprised to know that it is the practice of so many plants to isolate the mains being flushed. That is considerable of an effort, isn't it, Mr. Taylor?

MR. TAYLOR: We generally start at the end of our system nearest the reservoir. Of course, those are large mains. We shut off certain sections of one of the mains and feed it down through the other, thoroughly flushing that main in that section and take the next section and so on down through the whole city, isolating each section by itself. In most cases where it is not a straight run, but a roundabout run in sections, we let the water come through, first, one way and back the other way through the same section. For instance, if we shut off four or five gates to one section, we will flush it through one end first and then close that end and flush it through another end. It takes time and some effort, but we go through the whole city at least twice a year, flushing every inch of main in the city and filling it with fresh water. Dead ends are flushed more frequently, as the occasion requires. We find it well worth while to take the extra pains to do it systematically by starting at the source and working down with clean water all the way.

MR. CRAMER: It strikes me in a ten inch main or longer, if you do not shut off your pipes you are just going to stir the water. You do not get a flushing effect unless you have your main isolated.

CHAIRMAN PATTON: How many hydrants do you open at a time?

MR. TAYLOR: It depends on the size of the main. On our 4- and 8-inch lines we open everything on the line. On the 6-inch one or two hydrants will do. It depends on how many hydrants are available at the low point. In some cases we flush with waste gates into the sewers. We gauge the amount of flow through the pipe by the size of the pipe.

MR. HERSHLER: We isolate the mains and keep the hydrants open. We have five mains. We keep four lines open all the time to create

enough velocity to flush the mains. You do not get enough velocity to clean your mains unless you have the required number of openings to flush. We start at the flushing plant and we go right through, nightly. We flush every night and the hydrants are never shut. We have an automobile to take care of the man on the job, and that man does not shut off until another man comes to relieve him. In that way we can keep four hydrants open constantly all night. We create velocity enough so that we know we have a good, clear main.

CHAIRMAN PATTON: Mr. Dugger will you explain your method.

MR. DUGGER: We isolate two mains and go on down through the system. We are in a tidewater section and there are low points. We have a drain valve at the lower ends and we use that constantly. We have an 8-inch drain. If you keep open with all the plugs through you will have no difficulty.

We have four different municipalities and we have to use practically the same methods throughout. It is clearly a matter of isolation.

MR. LYON: May I ask if you ever take into consideration whether to flush the high or low points? In our city the ground is quite rolling. The high district or the low district first makes little difference in the flushing.

MR. HERSHLER: We always start with the pumping station. We have an upper and a lower system.

MR. LYON: We had a lot of trouble with our flushing at first and we followed the pipe line which carried the heavy load and flushed that first and left the dead ends to the last. We have gotten better results in that way.

HYDRANT VALVE CONNECTIONS—FLANGED OR LEAD JOINTS

W. S. PATTON: In these days of automobiles when our hydrants are being struck by them everyone is having trouble. Which type of joint have you found causes least trouble, the flange or lead joint between the auxiliary valves.

MR. CRAMER: You mean by that the lateral valve, do you not?

CHAIRMAN PATTON: The auxiliary valve, yes.

MR. CRAMER: Unfortunately, most of our plants were built before the automobile came and the fire hydrants we are now putting in are located in the parkways where we do not have that trouble. This question does not apply to the newer connections so much. But I am still setting them with lead joints. If I had the system to build over I would prefer the flange joint, but we have to take it as we have it.

MR. HERSHLER: I do not see the difference, when they break the hydrant they break the flange too. When the automobile goes over the curb it hits the hydrant or breaks it off at the top of the ground, then you have to take it up and put in a new valve. I have never known it to fail. And so far as locking them is concerned, it makes little difference, for when the automobile goes over it goes on to the boulevard and the hydrant goes too. We have them broken into on the boulevards sometimes ten feet from the curb.

T. F. HALPIN (Newark, N. J.): The drivers are getting more experience. It used to be nothing to find eleven or twelve hydrants knocked over in one night and now we sometimes go a whole year without one being knocked over. This year I think we had two. It all depends upon the type of hydrants. We use a cage type hydrant and the flange is down on the bottom. If the hydrant is struck the flange is not broken. We use a cam point for our joints when we use the lead pipe. It gives very good satisfaction. That type of hydrant is popular with us. We have been using it ever

since I have been connected with the city. I have changed in some other things, but I believe in sticking to a hydrant that gives satisfaction. Those hydrants were installed thirty-seven or thirty-eight years ago and they are still on the job.

MR. CRAMER: You know what kind of hydrant you are going to repair. That makes quite a difference. If you use the same type you are not bothered with losing parts and having trouble with the fittings.

MR. TAYLOR: I do not think it makes much difference whether the joint is a flange or a bell and spigot. The break occurs at the pavement line or at the bottom flange. I think it is more important that the valve be located as near the main as possible and as far away from the hydrant as is practical. We have several cases in the none-compression type of hydrants. You get a geyser when it is broken off and the men are unable to get at the independent valve. The further away you can get that from the hydrant, the more it will improve your condition.

There is a straight type of hydrant where the hydrant bearer cannot be knocked off. You do not have to shut down the line at all. It has a bronze nut on the sleeve where the hydrant wrench goes on. To take the plate off for replacement it is not necessary to shut down. Of course when you get the geyser right up through it that would be difficult.

MR. CRAMER: I understand the hydrant stays right in place.

MR. TAYLOR: I think there is an advantage in the gate type of hydrant.

CHAIRMAN PATTON: I think Mr. Taylor's idea is a very valuable one. What we need in the water works field is a change of practice. Instead of putting those auxiliary valves right at the hydrant, they should be placed as close to the main as possible. The hydrants are placed very close to the main; often there is a very short distance between the hydrant and the main.

I have been wondering for the past year if it would not be advisable to have a standard design, or valve box case. Say a hexagonal box, something altogether different from any ordinary valve box, to lock the valve to the hydrant right at the main. The chief objections to

putting these valves next to main is that someone might make a mistake and shut off the water main by that method. I have never had that happen in my experience, but it could happen. If it were customary to put the hydrant valve close to the main it would be hard to determine exactly which was shutting off the hydrants and which was shutting off the main, especially when you had a six inch main. If we could have a standard valve box made of unusual construction, so that there would be no possibility of getting an ordinary valve box lid on it then there would be no danger of shutting off the main by mistake when you intended to shut off a hydrant.

F. B. McDowell (Charleston, S. C.): As far as that goes, I think it is advisable to have the hydrant braced as near the main as possible. There is a possibility of confusion as to whether it is on the main or not. I do not know whether we should adopt a different type valve box to eliminate that possibility or not. It seems to me the superintendent could specify the standard valve box, with a different type lid, placed at every hydrant. You could have H. V. on the top of the lid. If that lid gets broken, there is a possibility of the wrong lid being placed on there, and if you had H. V. on the top of the lid of the hydrant valve there might be some advantage.

If you would adhere to the round top for the valve box you would find it a pretty good practice. I would rather have it than any other I know of, even the rectangular or hexagonal type.

Mr. Cramer: It has not occurred to me in the business district where the valves are located on property lines and the hydrants are from 10 to 12 and even 20 feet from the property line. We have never had this question of confusion. I never thought of it.

Mr. Kinder: Are we not getting away from the thought of the hydrants on the corner? Are we not moving them around the corner a little further now? In the days of the horsedrawn fire fighting equipment there was an argument for putting the hydrant on the corner, because it was available from two directions. In this day of the automobile I think we have all found it mighty convenient to have it 30 or 40 feet around the corner. I see no chance of making gate valves differently, because it is common practice to put all gate valves on property lines. Hydrant valves that far away are in a class by themselves and we have a chance to adhere to standards in our valve boxes.

CHAINS ON HYDRANT CAPS

CHAIRMAN PATTON: Do you consider chains on hydrant caps necessary? One member has found it to be more economical and desirable to use a chain between the caps than a chain from an eye-bolt in the dome of the hydrant.

First, let's take the question, "Do you consider chains on hydrant caps necessary?" Let's discuss it from the fire hydrant angle. The fire departments are opposed to them. The caps bind when you try to take them off. That delays the firemen. What is the consensus of opinion here? How many of you think that fire hydrant chains are advisable?

(Fourteen hands.)

CHAIRMAN PATTON: How many of you do not consider them really essential?

(Two hands.)

CHAIRMAN PATTON: Then do you prefer to use the chain between the caps and chain from the eye-bolt and the dome of the hydrant? Let's see how many.

(Eight hands.)

CHAIRMAN PATTON: How many prefer to use the chain between the caps? I suppose we may assume that the rest of you do prefer that.

GATE VALVES AND VALVE BOXES

S. B. Morris (Pasadena, Cal.): In Pasadena we operate every valve in the system up and down once a year. We have one or two men go around throughout the year to maintain the gate valves and repack such of those as show any leakage in the packing box or any other repairs which may be necessary. The majority of the work perhaps is taken up in replacing and repairing valve boxes, rather than in attention to the valves themselves, because we have not as much difference in our valves as in the valve box.

We find also many of the new valves, before installation, need more packing. It is our practice to open up the packing boxes and repack those that need it before installation.

C. M. Crowley (St. Paul. Minn.): The old practice was to make an examination every two or three years. I think it continues and probably with greater efficiency, for they examine some of the larger valves every year, some others every second year, and on the smaller mains and districts they are gone over each year or about every third year. We would probably give it a closer inspection, if our revenues would justify. We are carrying out a large construction program and our revenues are charged with the sinking fund and equipment that we will not use for twenty or twenty-five years probably, until our population is doubled, so we have to adapt ourselves to the revenue in hand.

Robert B. Morse (Hyattsville, Md.): We make regular inspection of our valves, operating them twice a year, fall and spring. We do just as the speaker from Pasadena does, operating them fully up and down, and we also back them off several times in order to work out any small material that may be in them. We find that works satisfactorily and in that way we are sure that the valve is tight.

We have much more trouble with the covering up and damaging of valve boxes, of course, than we do with the valves. In the Washington Suburban Sanitary District there are a great many small towns and unincorporated villages which lay down gravel or

cinder streets without any reference to the grade at which the top of the valve box happens to be and without any notification to our office. Therefore, we have to be on the job a good deal of the time doing observation work for ourselves and making such changes in the valve boxes as may be necessary.

W. S. PATTON: Is there any further discussion? This brings up an interesting question. Do you use valve boxes or do you use valve vaults with manholes for your valves, and what size valves do you usually provide with manholes?

MR. MORSE: We use the valve boxes on valves of 12 inches and under. On 16 inches and up we use the manhole.

MR. MORRIS: We use valve boxes on all ungeared valves and the manhole over all valves which have gears regardless of what that size is, usually 16 inches and up.

CHAIRMAN PATTON: Is there any further discussion?

G. A. CORINE (Superior, Wis.): We have conducted our own pitometer surveys ever since 1917 yearly. In making this survey we operate every valve. We have a practice of building vaults over all the valves that are 12 inches in size or larger, but lately wherever there is a possibility of paving the street in the near future we are putting in the vaults on all valves, no matter what the size.

F. W. LANE (St. Petersburg, Fla.): I think that we are probably stimulated and a great many others are to a much closer examination of valves by the Board of Underwriters. They have been in the service of our city every year or two, and we try to keep up with them. They go out and make their own tests; they do not like to be caught napping. It is quite a stimulus to keeping things in good shape.

SERVICE PIPES

ROBERT B. MORSE (Hyattsville, Md.): We are just starting to use the copper pipe on surveys of $3\frac{1}{4}$ inches; we have been using $1\frac{1}{4}$ cast iron pipe before this time.

F. W. LANE (St. Petersburg, Fla.): We have just started using copper. We have been using galvanized material, and we are trying out the $1\frac{3}{4}$ inch. But we have not gone far enough to know much about it yet.

CHAIRMAN PATTON: In using the copper and brass pipe no lead connection is required. The pipe is attached direct to the corporation cock. Do you use a corporation cock with that?

MR. LANE: Yes. We use a pipe and flange off to fit. They are made for that purpose, as on gas pipes.

MR. MORRIS: We use copper pipe for sewer flush connection where they go through the manhole. We had trouble with the corrosion of the pipes that go through the manhole until we adopted the full pipe.

Since we have started to use the copper pipe we have been omitting the lead, connecting the copper pipe directly to the corporation cock through a 45 degree fitting.

MR. LANE: We find it cheaper to do the same thing. Our help down there is all negroes and sometimes they cause a lot of trouble.

MR. MORRIS: There is one interesting thing we have in our old lines at Pasadena. We have a number of services, installed forty years ago from 1- to 2-inch wrought iron pipe, directly tapered into the cast-iron mains without any gooseneck. We have had no difficulty with those and they are forty years old. We have never had a cracked pipe or any broken pipe. But we do not follow that system now.

R. C. BEAM (Middletown, Ohio): It will probably be of interest to know that developments are being made at the present time for furnishing vitreous enameled pipe, pipe enameled on the inside as well as on the outside of small, as well as the larger, diameters, which will be used for service pipe. That will prevent corrosion from taking place on the outside and will increase the life of your pipe over a long period.

CHAIRMAN PATTON: I would like to ask in regard to this vitreous pipe, do you mean cast-iron pipe with some kind of enamel on the inside and outside?

MR. BEAM: It would be a plated pipe.

CHAIRMAN PATTON: Do you mean it would be a steel pipe that will have a vitreous external and internal finish?

MR. BEAM: Yes.

MR. LANE: What makes the joints in that?

MR. BEAM: The services I have seen have a slight coating of enamel with threads. I understand that the enameling companies have tackled the problem of making a plastic enamel. How far they are getting with it I do not know. They have run into some difficulty, but there seems to be a coating on the threads when the proper connections are made.

MR. LANE: Could we re-thread those in a certain length?

MR. BEAM: I do not know how they are going to handle that part. I just offered this as a recent development in the pipe field. The pipe is being made in a variety of lengths, enameled both on the inside and outside, and is being used in various phases of the pipe industry.

CHAIRMAN PATTON: It would seem to me that the chief weakness of a pipe of that kind would be at the threads. Where the threads are exposed to corrosion, the pipe tends to disintegrate, the same as any other steel or iron pipe.

MR. MORSE: I think the pipe would be no stronger than the weakest point in the chain.

MR. CORINE: Getting back to the question of copper pipe line, I am going to ask what is the general practice in case the service is torn out. If you have been using lead pipe, you will be interested in knowing that we have serious freezing, and when we get down on it we just pound it together again. We freeze our pipe and make our repairs. When copper pipe does not hold, we must dig down in the main and shut the water off or make a shut-off at the main.

CHAIRMAN PATTON: Mr. Corine has brought up an interesting question. With iron pipe it is feasible to freeze it, if you have thick walls, and you shut off the water in that way, but with this thin wall copper pipe if you freeze it it is liable to bulge up and weaken the walls. Has anyone had any experience in shutting off water in that way, with copper pipe?

MR. CORINE: I do not think you could pound it together to stop the flow of water with the pressure on it, so you could not freeze it in the first place.

J. P. HANLEY (Illinois Central System, Chicago, Ill.): I am a member of the American Railway Engineering Association and I am somewhat interested in the developments of small pipe for service lines. If there are any gentlemen present who have had experience with copper and brass, I would like them to state which in their opinion is the best. As I understand it the copper has a light wall thickness while the brass has a heavier wall thickness. In the case mentioned by Mr. Corine, would the use of brass pipe permit you to freeze that, instead of using the thin wall copper pipe?

MR. CROWLEY: As far as St. Paul is concerned I cannot speak from any personal knowledge, but it seems to me I have heard the discussion from some of our foremen and assistant superintendents and others, that the brass pipe is quite brittle, due to the quality of the pipe, and they had some difficulty with the threads.

MR. HANLEY: Do you use brass pipe in St. Paul?

MR. CROWLEY: We have experimented to some extent with it and have come down to the practice of iron or brass for anything of 2

inches or over. Where there is so much at stake, we find we are much better off. Our maintenance charge has increased as system gets older.

MR. HANLEY: Have you had any experience in the relative merits of copper in pipes? I saw an exhibit here which stated that there was 85 per cent copper which would do away with that brittleness. I was wondering if that would do away with the brittleness which you mentioned.

MR. CROWLEY: I think that was the idea, that they were waiting for some such product as that. With 2 inches or up, I do not know whether we would be inclined to commit ourselves to that or not just yet, but we feel sanguine.

MR. HANLEY: What I was trying to get an expression on was, say, a pipe under 2 inches in size, as to the relative merits of brass. I understand that copper is more ductile and can be bent like lead, although it has the disadvantage of having a light wall thickness. I was wondering whether any gentlemen had any experience as to the general all around merits of copper or brass.

MR. CROWLEY: I am afraid the subject is a little bit too new for certainty.

MR. HANLEY: In municipal practice it has appeared that lead has been the principal service heretofore and that they are now going over to copper in some cases, and possibly brass, so I was wondering if the experience had been long enough to give you an idea of current practices as compared with the copper.

MR. CROWLEY: We have been using copper for about two years, but that is hardly a sufficient length of time to be definite.

WILLIAM LUSCOMBE (Gary, Ind.): I was trying to collect some information about the merits and demerits of the brass and copper pipe. We use extra strong lead entirely at Gary. I spoke of it to a couple of superintendents who had used brass, and they stated they had had considerable trouble with the brass pipe breaking where it was threaded. It was brittle and gave considerable trouble in that way. I spoke to other parties who had used copper and they said

that it was preferable to brass. By learning how to use it and using the special couplings such as were shown in the exhibit room, they got away entirely from that. They seemed to recommend it very much in preference to the use of lead pipe or brass. One superintendent said it was about one-third cheaper than lead. He had used it a few years with very good success.

MR. CROWLEY: In St. Paul up to some years ago we used 2-inch lead pipe, but we find that at points of very heavy pressure we continually have an expanding effect. Then we adopted the practice of putting in galvanized iron, but in our community it is not very durable. Probably the quality of the pipe was reduced years ago and we did not know the quality of some of the iron, which was very inferior. We have given that up, therefore, and are putting in brass.

W. S. PATTON: We have almost discontinued the use of wrought iron pipe. We are using now for the smaller sizes, cast-iron pipe in $1\frac{1}{4}$- and 2-inch sizes, very satisfactorily, and even where we shove the pipe across the street. We have some rather wide streets at Ashland, and we first shove the wrought iron pipe across and then enlarge the hole by shoving a little bit larger size across and then we start in and shove the cast-iron through the hole. We have 2-inch cast-iron, belt and spigot pipe underneath that paving with perfect results. We have never returned to the use of galvanized pipe, because the cast-iron pipe gives us so little trouble from electrolysis, whereas the wrought iron was eaten out in such a short time.
It is not an infrequent occurrence to renew the same service line once a year, but with the cast-iron we seem to be having freedom from this trouble. If we could obtain cast-iron pipe in a $1\frac{1}{4}$- and 2-inch size, cement coated, we would have the ideal material to use in our smaller service lines.

MR. CROWLEY: What lengths of pipe do you use?

CHAIRMAN PATTON: These are, I believe, in 5-foot lengths, with two joints attached, which gives us a 10-foot length. They are made by the McWane Cast Iron Pipe Company, although there are other foundries now turning out the same kind of pipe.

MR. MORSE: We have used for a number of years the 1¼-inch McWane pipe and have found it very satisfactory. The only trouble we have had at all, which is really not the fault of the pipe, is that we make most of our service connections in the sewer connection trench. We do that because we save a great deal of money in construction. We simply place our service 4 feet in depth and dig a small trench on the side of the sewer connection trench and then we place it across. We have had perhaps two or three dozen instances in the whole four or five years that we have used that form of construction, that the 1¼-inch pipe has sheared off, but we find that it is better to take a little more maintenance cost once in a while in order to gain the economy of putting the pipe in the sewer trench.

We make some 3000 water and sewer connections each year, and of course in that way the total savings in constructions are very large.

MR. HANLEY: In your cast-iron service pipes what kind of cock do you have at the curb?

CHAIRMAN PATTON: With the 1¼-inch cast-iron we can use an ordinary 1¼-inch cock. This bell and spigot pipe is supplied with short pieces if you want them, there being a nipple bent on one side and threaded on the other, in almost any kind of shape you want to get it. I believe you can get it now with the T's cast in it or you can get a full length of cast-iron with a bell on one end and threads on the other end, and you screw your T into that. It is very flexible.

MR. HANLEY: Do you use the regular lead gooseneck on that?

CHAIRMAN PATTON: You can tap it. Even though you do not use those bosses, it might be that that could be tapped with the corporation cock. I am not sufficiently familiar with that to say. I am afraid you would have to use a saddle or clamp.

MR. LANE: We put in about two miles of the 1¼-inch pipe in St. Petersburgh. We do not use the saddles. We tap the bosses where they come off the larger pipe and use a corporation cock. There is also any combination you want. They furnish threaded nipples so you can have a spigot on one end, or the bell or spiral is put on the other end.

MR. MORRIS: Our method seems to be a little bit different. We make a practice of using 2-inch only rather than using the 1¼-inch. We install them along the dividing line of the property so they can take care of two service connections. The meters are being set side by side at the property line. The connection at the main is made with a double corporation cock and then a combined bell and thread piece is screwed onto the corporation pipe and the pipe connected into that fitting with a lead gasket, or rather a lead joint.

We make a great deal of use of that double connection. It saves you a great deal, although we use it in the 1¼-inch size of main pipe. We set our meters near the property line or near the curb as the case may be, and simply bring the 1¼-inch pipe from the main to the meter box. Then we make or have a riser of wrought iron, just using that piece of wrought iron in the box and set the meters in meter boxes. The two meters can be placed in one box, the two pipes coming out one from each meter, and going to the respective properties. Of course, the services to the property line are maintained by our organization and the services are separated before they enter on private property. In case of any particular trouble only one house need be shut out of water besides the one you are working on.

We do not use any curb boxes at all, using the type of meter yoke which has a cut-off in the yoke.

Do you have any shut-off on the cast-iron pipe itself at the curb?

MR. LANE: No, no shut-off on the cast-iron pipe itself at the curb, just simply in the meter box after you have come up in the meter yoke. Do you install them in both places?

MR. MORRIS: We have not found that expenditure necessary. We have had no trouble in the shutting off of the yoke itself, so we think that saving is justified. In other words, in general, it is better to take a little grief possibly on the operating side in order to make a large saving on the construction. We do that in a number of instances, just as I said a little while ago in putting the water connection in the same connection as the trench. We later have a little trouble in the connection in order to make the saving.

CHAIRMAN PATTON: We use that kind of line where we require 1-inch or a little bit larger pipe. At present we are using ¾-inch Byers wrought iron galvanized pipe, and our experience has been satisfac-

tory. I believe though that it is only going to be a question of a little while until we will be using the thin walled copper pipe. That is the reason I am so interested in the present discussion.

MR. CROWLEY: In St. Paul, in many cases the sewer connection will be down 20 or 25 feet. We have made it a practice for years to keep away from the sewer ditch. We try to make a straight line from the main to property line and the sewer follows the slope of the connection, so sometimes we keep on the ledge. We find this fill or deep sewer trench would be apt to pull away and loosen it. We tried to keep at just the depth of our own water main and have a solid bottom as far as possible. We have had had experiences the other way. Of course, in many cities the difference in depth between the sewer and water main is not so marked.

MR. MORSE: We have all kinds of conditions. We have very rough and some level topography. We go from tide level to 500 feet elevation, and our sewers are generally laid, where possible, at a 6-foot depth. Of course in many cases we get in deep too. We never lay the water line in the street in the same trench with the sewer, but I was speaking only of the connection.

MR. CROWLEY: We follow that practice to property line.

CHAIRMAN PATTON: We got into an interesting discussion in regard to meter yokes. There is something that is going to be used more and more universally. I would like to hear from Mr. Luscombe. Do you use the meter yoke or riser or place your meters in basins?

WILLIAM LUSCOMBE: We do not use the meter yokes. Practically all our meters are inside settings. It so happens that our company furnishes the gas and electricity as well as the water to the citizens of the town. It is necessary for them to go into the premises to read the gas and electric meters. For that reason it is more practical to have inside settings for water meters. The meters are placed near the basement floor, where the pipe enters the building, and from that pipe there is a riser pipe from the basement ceiling joists which passes on to the various parts of the building. There is always a stop cock in the service pipe just at the meter inlet for turning off and draining the pipes.

DONALD H. MAXWELL (Chicago, Ill.): I am young in this game and I would like to ask some of the older heads why you use lead goosenecks in connection with galvanized and wrought iron and steel pipe. Why would it not be just as well to tap the pipe into the main?

MR. LUSCOMBE: It is put there to give flexibility to your service line. In case of a slight contraction or expansion also, it will not cause any pull on the joints to weaken or produce leaks.

MR. MAXWELL: Would it not be necessary to use that lead gooseneck with the copper or brass pipes?

MR. LUSCOMBE: We have never used copper pipes. I am not prepared to say.

CHAIRMAN PATTON: It would not be necessary to use a gooseneck with copper pipe because you can create a gooseneck yourself. After you leave the main you can easily bend it into a gooseneck to take care of any expansion or contraction.

MR. LANE: You can bend the copper pipe, just the same as the lead. We are doing away with the lead. I might say we do not have to go very deep so we use a concrete meter box with a meter and curb cock inside the box.

CHAIRMAN PATTON: Mr. Lane, in setting your meters you simply bend the copper pipe, don't you? The pipe is of sufficient strength to support the meter.

MR. LANE: We start out from the main with the cast-iron pipe, make the tap there and gradually rise up so we have our meter setting 8 inches below the surface. We put our meters in one corner of the parking and the parking is generally grassed over. We have the concrete meter box, with the box painted green. In this territory it lasts as long as cast-iron, and it makes a simple and cheap construction. It would not apply in many places.

MR. PATTON: I wonder, on a deeper setting than they have in Florida, whether we could bend the pipe up and run it directly into the meter yoke. So far we are using an L at the end of the pipe and

are still using the wrought iron riser. I should like to do away with that if there is rigidity enough in the copper pipe.

MR. HANLEY: You could use brass pipe for that purpose, couldn't you?

MR. LANE: Yes, we could, but I do not see any particular advantage in using brass pipe. In case of deterioration of wrought iron pipe it is so easy to get at, and it does not seem it would be necessary to go to the expense of short brass pipe. I think in case of repairs we would shut off one block of the distribution system.

MR. HANLEY: If you had this short life pipe inside your curb box then I think it would be all right, but if any of this short life pipe is outside of the curb box it looks as though you would have to go to the corporation cock.

MR. LANE: We would not do that. We would shut down one block of the pipe system.

MR. HANLEY: You could not do that in a great many cities.

MR. LANE: But at any rate there are so many galvanized iron services on the system, I do not think we would take much account of the short length in the meter boxes themselves.

MR. CROWLEY: One of the great advantages is that you can curve the copper so it will allow for slippage and your pipe will adjust itself for the settling of the ditch. In our city we lay them 7 feet deep and sometimes there is quite a settlement, depending on the kind of fill. By making this allowance it will adjust itself to any reasonable settling of a ditch. Of course a rigid pipe would hardly do that.

MR. HANLEY: It appears to me from what I have heard that the question of service pipes might be divided into two classes. One would be corroded and the other a non-corroded, such as copper, brass or lead. Of all classes of iron or steel pipe it looks like the cast-iron is the most durable and pretty nearly as cheap as the other. If you have conditions where you require 2- or 3-inch services, it looks like the proper procedure would be to put in cast-iron pipe. If you

have conditions that require service of 1-inch or ¾-inch pipe, then the question is to put in either brass, lead or copper. I would think that the question of a 1-inch and over sizes is pretty well solved, but the question of other sizes seems to me to be the cause of a difference of opinion. Most people are swinging from the lead to the copper or brass.

CHAIRMAN PATTON: I believe that expresses the current opinion on the question. Is there any further discussion?

CHAIRMAN PATTON: The next question is "Have you found by actual experience that wrought iron service lines out-last steel?" That is an old, old question. Have you had any actual experience on this? Have you ever buried an iron pipe and a steel pipe about the same time and have you ever taken the trouble to tear it in two?

MR. MORRIS: Everyone has made this observation, that all of our service piping, before the advent of the Bessemer process, was of puddled pure wrought iron pipe. Our general experience is that those pipes are much older than the pipes laid in the later 90's and up to 1910, say, which are generally in better condition than are the pipes laid at a later date. On that basis, we of the water system adopted the pure iron pipe made by Byers, Greeley & Company, or any of the companies putting out pure wrought iron pipe.

R. C. BEAM: I was in Mr. Cotter's office about a month ago. He is water works superintendent of Springfield, Ohio, and he showed me three samples of pipe. He is a man sixty-five years old and has had a world of experience. One sample was cast-iron, one wrought iron and one steel galvanized, with no galvanized iron. The cast-iron was in perfect condition. There was absolutely no corrosion taking place on either the inside or the outside. The wrought iron was not in so good condition; there seemed to be pitting. The steel that was galvanized was pitted all the way through.

Mr. Cotter stated the cast-iron had been in service twenty-seven years; the wrought iron a similar amount of time, and the steel about three years. He has seen those three pipes come and go, and that has been his experience.

MR. VOSKIN: We have considerable steel pipe in our service, some of it about twenty years. However, it all has a protective coating on the outside. I mean that, in addition to the dipping, it has a sort of burlap wrapping around it. A recent examination was made which discloses that it is in practically as good condition as it was twenty years ago. Ours is sandy soil, and it is rather difficult to estimate the life of pipe, but only a slight deterioration has taken place so far.

CHAIRMAN PATTON: What was the diameter of the pipe?

MR. VOSKIN: It ranges from 3 to 12 inches.

PROPER SIZES OF METERS FOR DOMESTIC SUPPLY

MR. CROWLEY: Three-quarter-inch is now what we use in St. Paul. Sometimes there are four and even as high as six flats. Another man comes in and cannot get along with one inch. He must have a 2-inch for six flats.

MR. HANLEY: Speaking from the railroad point of view, we have found when we ask for a 4-inch meter we usually get a 2-, so I think you fellows have that down pretty well.

MR. MORRIS: We charge a sliding scale of minimums which make those who want larger service pay all the costs, so that we do not worry so much if they want larger service. We have a minimum charge, based not alone on the interest, depreciation, maintenance and operation and meter service, but also on the increased amount of unregistered water that will take place with the larger service. The larger service they get the harder they are hit on the monthly cost.

In general, most of our consumers have the $\frac{3}{4}$-inch meters. We will install a 1-inch meter for anybody who wants it. In general, those who have lawn sprinkler systems, have the ground completely piped with sprinkler sets, with 8-, 10- or 12-foot centers, so they can turn on the water. They are the ones who want the larger service for domestic consumption. Our rule is that anyone who wants a service connection larger than 1-inch for domestic purposes, makes application to our domestic department and they decide what size they can have. The meter service clerk is not authorized to issue anything larger than 1-inch in diameter until it is referred to the engineering department, where it is determined consistent with the size of the ground.

MR. MORSE: We are in much the same situation as Pasadena. We do not worry quite as much as we would if we did not have a service charge. We charge four dollars a year as a true service

charge for a $\frac{5}{8}$-inch meter, seven dollars for $\frac{3}{4}$-inch and twelve dollars for 1-inch, up to $360 a year for the 8-inch meter. Most of the residences have the $\frac{5}{8}$-inch meter, but anybody can make an application for any size wanted. If the application is all out of reason for its service, we simply try to argue the matter out with the applicant. We have found both plumbers and architects have given us a great deal of trouble. They always seem to want a meter of the same size as the house connection. Very often we gain the point with the applicants by saying we will put in a $\frac{5}{8}$-inch meter, and, if it does not do what they want, we will put in a $\frac{3}{4}$-inch meter. We tell them that they had better try to save the cost. We seldom have anybody come back for the larger size meter. Those who do come back are generally those who use the flushometer. That is giving us a greater amount of trouble now than it used to. I hate to bring it up in this meeting, because I know what it generally leads into.

MR. RUSKIN: I believe the size of the meter and the size of the tap are somewhat determined by the pressure in the system. With us we carry about 50 pounds domestic pressure for domestic service. Almost all of our meters are of the $\frac{5}{8}$-inch size. We do not have any trouble except in special cases where they have the flushometer toilets. For larger sizes application is made and any application that is sought is numbered. The number, kind and fixtures and other uses to be made of the water are noted. From that information we determine what we consider will be the proper size meter for the place. Meters are read monthly and by checking the monthly consumption, in some instances where special uses or miscellaneous use is made of the water, by getting what you might term the peak load when industries or enterprises are carried on in full blast, one can determine whether the proper size meter is installed for that service.

There is a rather interesting device in the exhibit room. It is a flow recorder. It is a mechanical device so that the chart indicates the rate of flow through the meter throughout the twenty-four hours. If that is properly developed and not too complicated, it should be quite an aid in determining the proper size and type of meter for various classes of service.

CHAIRMAN PATTON: It seems to me that what we need is a curb workout so that taking the number of occupants of an apartment

building and the number of fixtures, we could pretty accurately determine the amount of water that is going to be required. Our chief difficulty though lies with the architects, who invariably specify from 50 to 100 per cent larger meters than are really required.

MR. CROWLEY: I find the architects do not consider it is worth while to come to the office to get any information on the subject. I have been trying to keep silent on the question, because we have been rather perplexed trying to determine by some such scale as this. We have a clerk to determine the requirements for each fixture. He gets the total and discounts it by a certain per cent according to the pressure.

MR. HANLEY: In Chicago I have had considerable experience in negotiating with the city water department in services for the railroad. I am familiar with the department's ruling. They feel bound only to deliver the water at the surface of the ground at your premises. For instance, this hotel, sixteen stories high, and the Morrison, fourteen stories high, have roof tanks or house pumps. The city is under no obligation to give pressure to such great heights. In other words, the ordinance is that they shall give water to open tanks, and from that open tank it is elevated to whatever height you wish. I presume that such a condition would prevail in St. Paul, but in smaller towns I do not know.

MR. CROWLEY: We try to keep a minimum of 30 or 40 pounds for fire protection. We hardly feel that we have fire protection under forty pounds.

MR. HANLEY: If you go down in the engine room in the basement of this hotel, very likely you will find an open service tank. The water comes into that open tank. There is no open connection. A reservoir receives the water below. It is pumped from the open tank to the higher floors. They do a little better than the city of Chicago, giving 20 or 35 pounds of pressure. I have had occasion to remonstrate with them in the various outlying districts when we take water. I have always been told that the city does not feel obligated to do your pumping for you. They will furnish the

water and if you cannot get along with their pressure you can put in a tank and pump it. That is the case 20 miles from the heart of the city. While they are extending the mains and getting larger connections now, they are constantly improving. I know in the last ten or fifteen years, the outlying users have had considerable difficulty on account of low pressure. I have just finished a trip through this tunnel this morning and I see where they are putting in a 16-foot tunnel. I know they are making a great effort to get an adequate water supply.

SOCIETY AFFAIRS

MINNESOTA SECTION

The Minnesota Conference on Public Utilities met in a joint session with the Minnesota Section of the American Water Works Association in one of the company rooms of the Minneapolis Armory, Minneapolis, Minnesota, at 10 a.m., June 15, 1927.

Meeting was called to order by Felix Seligman, Chairman of the Minnesota Section.

A paper on "Elimination of Odor and Taste From Public Water Supplies by Aeration" was presented by R. A. Thuma. Questions were asked by Mr. Bang and Mr. Gallaher.

Following Mr. Thuma's paper, J. W. Kelsey, gave a paper on "Copper Service Pipes."

In Mr. Kelsey's paper he outlined St. Paul's ordinance in regard to installation and maintenance of the service pipes by the city in which they run service pipes to property lines and maintain them for a period of thirty years for a fee of $39 on a $\frac{3}{4}$ inch pipe. This price is standard on 66 foot streets. The work is let to contractors who must furnish bond and installation is made under inspection.

Questions were asked by J. A. Jensen, F. E. Patterson and Mr. Bang.

Mr. Gallaher of Aluminate Sales Corporation, Union Stock Yards, Chicago, Ill., followed with a short talk on sodium aluminate.

The Minnesota Section stood adjourned until 2 p.m., June 16, at which time the minutes of the last meeting were read.

Resolutions offered by the Illinois Section were discussed. Mr. Jensen stressed the need of some plan to prevent the overloading of water supplies with pollution. Mr. Jensen made a motion that we adopt the resolution and let it stand. Motion carried.

Chairman Seligman announced the report of the nominating committee. G. C. Pruett, Chairman; J. W. Kelsey, Vice Chairman; D. A. Reed, Trustee. On motion they were declared elected. The executive committee reappointed R. M. Finch, Secretary.

Members and visitors present numbered 34. On motion the conference adjourned until the 1928 convention.

DISCUSSION

EXPERIENCE WITH TURBINE TYPE WATER METERS

Our experience at Charleston with the turbine type water meter has been rather annoying at times. The difficulty has been that the meters over-registered due to accumulation on the vanes of the turbine, so that the loss of head through the meter increased, and then, in order to discharge the same quantity of water, the speed of the turbine wheel is increased. We have had them show as much as 30 per cent over-registration within a few days after being installed. Of course, this is an extreme case where yarn was working out of the joints in the mains and lodging on the vanes. Until recently, in all our turbine type meters, the water passed through the sides of the top and bottom of the piston and then discharged through the center of the piston. Possibly the single type runner is not so susceptible to over-registration from the cause above described, but we have had no experience with this type.

Recently we have installed in our turbine type meters a piston of a new design and so far the meters appear to be registering properly. The chief difference in the design consists of a casing around the propeller of the piston so that all of the water must enter both ends of the piston and impinge against the turbine blades at right angles to the plane of the blade; furthermore, the flutes of the wheel or blades are beveled toward the periphery so that when material tends to lodge on the blade, it is worked out toward the periphery and through the meter. We are not satisfied that this modified type of piston is going to be the solution of our trouble, but we hope so. The over-registration in nearly every case has been due to fibrous material from the joints in the main or from flax packing that has escaped from the pump. We do not use fish traps or screens in front of these meters, since in our opinion this protective apparatus imposes too much resistance to the flow of water.

J. E. GIBSON.[1]

[1] President, American Water Works Association; Manager and Engineer, Water Department, Charleston, S. C.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of issue, and 16 to the page of the Journal.

Spectrographic Analyses of Residues of Mineral Water. I. Water of Salsomaggiore. C. PORLEZZA and A. DONATI. Ann. chim. applicata, **15:** 535–42, 1925. Chem Abst., 20: 1370, May 10, 1926. Spectrographic examinations and chemical analyses were made of Salsomaggiore water. No element was found by one method and not by other. Spectrographic determination of barium (method described) indicated content of 0.0162 p.p.m. Previous chemical examinations reported only traces, no quantitative data being included. Results indicate that spectrographic examination is as reliable as chemical analysis for identifying elements present in residue of water.—*R. E. Thompson.*

Carbonates and Bicarbonates in the Water of the Nile. V. M. MOSSÉRI. Bull. inst. Égypte, **7:** 155–62, 1925. From Chem. Abst., **20:** 1479, May 10, 1926. Data of carbonate and bicarbonate content.—*R. E. Thompson.*

Chemical and Chemico-Physical Researches on the Saline Water of S. Venera (Acireale) which Contains Bicarbonates, Hydrosulfides, Boric Acid, Bromine, Iodine and Lithium. R. NASINI, C. PORLEZZA and A. DONATI. Ann. chim. applicata, **15:** 484–518, 1925. From Chem. Abst., **20:** 1480, May 10, 1926.—*R. E. Thompson.*

Chemical Analysis of Capvern Water. CH. LORMAND. Compt. rend., **182:** 404–6, 1926. From Chem. Abst., **20:** 1480, May 10, 1926.—*R. E. Thompson.*

The Hydro-Electric Plants of Rempen and Sieben in the Canton of Schwys, Switzerland. The Barrage Reservoir of Wäggital. A. BIDAULT DES CHAUMES. Genie civil, 87, 241–5, 1925. From Chem. Abst., **20:** 1481, May 10, 1926. Most important development in Switzerland. Reservoir will contain 148 million cubic meters, retained by dam 100 meters high. Fall utilized is 240–260 meters.—*R. E. Thompson.*

Modern British Practice in Water Softening. V. Zeolite or Base-Exchange Methods of Water Softening. D. BROWNLIE. Ind. Chemist, **2:** 61–4, 1926; cf. C. A., 20, 637. Chem. Absts., **20:** 1479, May 10, 1926. Advantages of zeolite water softening (doucil, kenzelite, permutite) are: (1) zero hardness,

(2) ease of dealing with all quantities of water, (3) no sludge, (4) simplicity of plant, (5) operation under pressure, (6) small floor space, (7) no moving parts, (8) alkali beneficial in boiler water and for laundry and bleaching plants, (9) easy control of exact hardness. Disadvantages are: (1) Alkaline water is cause of foaming and priming, and at pressures above 150 pounds per square inch tends to render boiler plate brittle. Such water is objectionable for drinking and cooking, also in dyeing, brewing, and other fermentation processes. (2) The zeolite disintegrates. (3) Carbon dioxide has solvent action on zeolite. (4) Acids act on zeolite. (5) Iron in water precipitates on zeolite as ferric hydroxide and lessens effectiveness and rate of regeneration. (6) Traces of oil in water gradually cover zeolite with fine film and render it useless. (7) Suspended matter must be first removed. (8) Size of plant depends on hardness of water. (9) There is nothing to prevent unsoftened water passing through filter when zeolite is exhausted. (10) Zero hardness is not necessary since 1° or 2° of hardness does not cause precipitation of magnesium and calcium salts of fatty acids. These remain in solution and act as detergents. Zeolite methods are ideal for water of moderate hardness, not over 12-15° total with little or no temporary hardness. For very hard water with little permanent hardness the lime-soda method is infinitely superior.—*R. E. Thompson.*

Stream Pollution. KENNETH ALLEN. Proc. Am. Soc. Civil Eng., 52, 520–31, 1926. From Chem. Absts., **20**: 1480, May 10. 1926. Symposium of results of Metropolitan Sewerage Commission. Standard of cleanliness proposed for New York Harbor.—*R. E. Thompson.*

The Presence of Iodates in Well Water. C. F. HICKETHIER and ALBERTO JACOBUCCI. Z. anal. Chem., **67**: 129–33, 1925. From Chem. Abst., **20**: 1480, May 10, 1926. In examination of waters from Argentine Republic, presence of nitrites was indicated by testing with Trommsdorff's reagent, but subsequent investigation showed that test was due to iodates. Reactions of Ilosvay v. Ilosva and Riegler are most reliable and sensitive tests available for nitrite.—*R. E. Thompson.*

Relation Between Stream Pollution and Extent of Sewage Treatment Required. J. K. HOSKINS. Proc. Am. Soc. Munic. Improvements, **31**: 317. From Chem. Abst., **20**: 1481, May 10, 1926. Point of maximum concentration of B. coli occurs 10 to 15 hours in summer and 15 to 30 hours in winter below sewer outlet. Bacterial decrease is more rapid in summer than in winter. It is possible by knowing maximum concentration to predict number of B coli remaining in stream at stated intervals of time and distance from sewer outlet. Permissible limit of B. coli in raw water to be purified is 1000 to 1200 per cubic centimeter. B. coli per cubic centimeter permissible at maximum concentration can then be calculated, considering time of flow from point of contamination to water plant.—*R. E. Thompson.*

Soaps as Integral Water-Proofings for Concrete. A. H. WHITE and J. H. BATEMAN. Proc. Am. Concrete Inst., 1926, (preprint). From Chem. Abst.,

20: 1506, May 10, 1926. Soaps added in concrete mixer are effective in preventing absorption of water by capillary action—as little as 0.05 per cent fat acid on basis of weight of concrete being sufficient. Strength is not impaired by such small quantities of soap provided concrete is kept damp continuously until it has attained desired strength, and provided soap has not caused foaming and entrainment of air. Soaps will not prevent penetration of water through cracked concrete, but will retard penetration of water into dry concrete. If concrete is kept damp until properly cured there should be only slight diminution in strength due to water-proofing, and conditions may arise in service where strength is increased.—*R. E. Thompson.*

Purifying Water By Use of Barium Silicate (to Remove Hardness). A. L. GRANT. U. S. 1,574,477, February 23. From Chem. Abst., **20:** 1482, May 10, 1926.—*R. E. Thompson.*

Apparatus for Purifying Water By Ozone. H. B. HARTMAN. U. S. 1,574,389, February 23. From Chem. Abst., **20:** 1482, May 10, 1927.—*R. E. Thompson.*

Effect of Lime on Concrete Products. P. C. CUNNICK. Proc. Am. Concrete Inst., 1926, (preprint). From Chem. Abst., **20:** 1506, May 10, 1926. In general, results of nearly 2000 specimens varying in mix, lime content, age, curing conditions, etc., indicate that (1) appearance of product is improved by all percentages of lime; (2) up to 40 per cent by weight, hydrated lime gives an average increase in strength of approximately 1 per cent for each pound of lime added per sack of cement—all percentages of lime tested showing increase in strength from 28 days to 6 months; (3) absorption is increased, as determined by standard immersion method, but not increased as determined by impounding water on one face; (4) permeability as determined by impounding water on one face is eliminated by using 20 per cent or more of hydrated lime; and (5) penetration of dampness into product decreases as lime is increased.—*R. E. Thompson.*

High-Test Bleaching Powder: Calcium Hypochlorite and Basic Calcium Hypochlorite. SABURO URANO. Trans. Am. Electrochem. Soc., **49:** (preprint), 1926. From Chem. Abst., **20:** 1965, June 20, 1926. U. succeeded in obtaining calcium hypochlorite and basic calcium hypochlorite in crystalline state, using bleaching powder as starting material. These compounds are more active and more stable than bleaching powder. Calcium hypochlorite and calcium hydroxide combine to form crystalline $Ca(OCl)_2 \cdot 2Ca(OH)_2$ for a definite condition of liquid phase. This compound gives bleaching powder of higher available chlorine (40 to 48 per cent) and of greater stability than ordinary bleaching powder. Calcium hypochlorite solution free from calcium chloride can be obtained by dissolving the basic salt in water. By evaporation of the hypochlorite solution in vacuo (25–50 mm. mercury, 30 to 40°), U. produced calcium hypochlorite in crystalline state purer than that made by older processes. By drying the crystalline hypochlorite the highest test bleaching powder, containing 90 to 95 per cent available chlorine, was obtained.—*R. E. Thompson.*

Geophysical Methods in Ground and Water Studies. E. LINK and R. SCHOBER. Gas u. Wasserfach, **69**: 225–8, 1926. From Chem. Abst., **20**: 1971, June 20, 1926. Various physical methods employed in locating ground water outlined.—*R. E. Thompson.*

Oxidation in Sea Water. H. W. HARVEY. J. Marine Biol. Assoc., **13**: 953–69, 1925. From Chem. Abst., **20**: 1997, June 20, 1926. "Deep water" from English Channel contains a catalyst which increases rate of oxidation of easily oxidizable substances such as pyrogallol and quinol. Decomposition of hydrogen peroxide is also catalyzed by deep water. Suggested that catalysts are organic compounds of iron and that inactivity of surface water is due to presence of oxidizable organic matter. When these substances are oxidized by hydrogen peroxide the surface water becomes more active.—*R. E. Thompson.*

Nephelometric Determination of Calcium and Magnesium. II. LEONIA KRISS. Biochem. Z., **162**: 359–65, 1925; cf. C. A. **20**: 1041. From Chem. Abst., **20**: 1772, June 10, 1926. In 50 per cent alcohol, calcium and magnesium can be determined by precipitation with ammonium ferrocyanide. Calcium alone can then be determined by precipitation with sodium sulforicinate. Method suitable for water analysis.—*R. E. Thompson.*

A Method for the Microscopic Analysis of Sediments. G. LUNDQUIST. Geol. För. Förh., **48**: 48–60, 1926. From Chem. Abst., **20**: 1779, June 10, 1926. Method described for examination of sediments, mixed with water and glycerol, under microscope with Nietz micrometer attachment to determine size of such constituents as calcite, sand, loam, pyrite, coarse detritus, fine detritus, pollen, spores, diatoms, etc.—*R. E. Thompson.*

Opinion and Decision of the Railroad Commission of Wisconsin in Reinvestigation of Pollution of Flambeau River at Park Falls. Decided February 20, 1926. Pub. Health Eng. Absts., March 20, 1926. From Chem. Abst., **20**: 1876, June 10, 1926. Summary of evidence presented before the commission regarding stream pollution by pulp and paper waste and its effect of fish life. Bibliography included.—*R. E. Thompson.*

Corrosion Due to Magnesium and Calcium Salts. D. C. CARMICHAEL. Power Plant Eng., **30**: 411, 1926. From Chem. Abst., **20**: 1876, June 10, 1926. Dissociation of calcium and magnesium chlorides and nitrates by high temperatures and pressures causes formation of acids which corrode boilers. Formation of scale prevents discovery of corrosion until cracks are formed.—*R. E. Thompson.*

Operation of Rapid Sand Filtration Plant of Cambridge, Mass. MELVILLE C. WHIPPLE. Water Works, **66**: 121–23, 1927. Because of the necessity for economy, the wash water was returned to the coagulation basins. The coagulation basin was unable effectively to remove this additional load of impurities, so chlorination of the raw water was adopted. This did not overcome

the detrimental effects of adding the wash water to the coagulation basins. An experimental wash water discharge line to the sewer was installed, and after trials had proved the advantages, discharging to the sewer was adopted. Difficulties with clogging of a 2½-inch alum feed line led to the adoption of periodical flushing from a pressure line and treatment with chloride of lime as the best routine treatment. New sand was added to the beds which increased the effective size from 0.38 to 0.45 mm. and reduced the uniformity coefficient. This has increased the filter runs somewhat, and has shown no detrimental effect on the filter effluent. Once a year each filter is allowed to stand overnight with 0.2 per cent solution of NaOH. A record of the quality of the water is given and the changes which have taken place in the water of Fresh Pond since the storage time has been increased are described.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

New Water Supply of Kingston, N. C. JOHN E. WEYHER. Public Works, **58**: 93–4, 1927. The old supply, which had become inadequate, consisted of 12 wells of various sizes from 3-inch to 10-inch and from 290 to 510 feet deep, with a total capacity of 380 g.p.m. A new well was drilled having a 38-inch casing the first 90 feet, a 24-inch casing to the 190-foot depth, and an 18 inch casing from the surface down 302 feet. Below this it has an 18 inch shutter screen in a 48-foot sand stratum. The sand and mud in the water bearing stratum were replaced with unifom size round filter gravel, and a total filtering area at the point of separation of approximately 490 square feet was obtained. The well was equipped with a Layne deep well turbine pump directly connected with a Westinghouse motor and delivered under test 871 g.p.m. with a drawdown of 46 feet.—*C. C. Ruchhoft.*

Water Supply of Anacartes, Wash. WM. B. SHORT. Water Works, **66**: 125–6, 1927. The new water supply of Anacartes is pumped from Lake Campbell to Whistle Lake and again to the filter plant. The water is treated with alum, aërated, settled, filtered, and chlorinated. Both pumping stations, the equipment of which is described, are operated by remote control from the filter plant, which has 4 gravity type filters 12 feet x 12 feet, with a capacity of 500,000 g.p.d. The cost of filtration is $7.87 per million gallons, and the total cost to the consumer is $36.43 per million gallons.—*C. C. Ruchhoft.*

Apparatus for Measuring Turbidity and Colour of Water. W. OLSZEWSKI. Chem. and Ind., **45**: 50, Dec. 10, 1926; Chem. Ztg., 1926, **50**: 694. The water under examination in a tube 20 cm. long is compared with distilled water in a similar adjacent tube by means of a half-shade photometer. The colours of the two are matched by the insertion of suitable coloured glasses, while the relative turbidities, against Ostwald's normal white, are determined by varying the amount of light passing through the distilled water by means of a graduated slit. (F. R. E.)—*A. M. Buswell.*

Treatment of Water for Use in the Manufacture of Artificial Silk. Brysilka Ltd., and F. W. SCHUBERT. (E. P.262, 369; 4.8.25). Chem. Ind., **46**: 7, Feb. 18, 1927. Water is fed into a de-aërating chamber in which a vacuum is main-

tained, the dissolved air being thus liberated and part of the liquid vaporised with consequent cooling of the system. (B. P. R.)—*A. M. Buswell.*

Physico-Chemical Processes Involved in the Removal of Manganese from Drinking Water. I. Adsorption of Bivalent Manganese by Manganese Dioxide. J. TILLMANS, P. HIRSCH, and F. HÄFFNER. Chem. Ind., **46**: 11, March 18, 1927; Gas u. Wasserfach, 1927, **70**: 25–30, 58–63. A study has been made of the adsorption of manganese by manganese dioxide from solutions of manganous sulphate which contained also a carbonate-bicarbonate buffer mixture. Equilibrium is attained after about one hour's shaking. The adsorption is reversible and increases with rise of temperature. It is concluded that the manganous ion is adsorbed directly, an equivalent quantity of sulphuric acid being liberated. The amount adsorbed for a constant pH varies with the equilibrum concentration of the solution according to the Freundlich adsorption isotherm, whilst for a constant end concentration the amount adsorbed is a linear function of the pH value. (A. B. M.).—*A. M. Buswell.*

Chemical Tests for Fecal Impurities in Drinking Water. R. SCHMIDT. Chem. Ind., **46**: 11, March 18, 1927; Gas- u. Wasserfach, 1927, **70**: 77. The indican test proposed by JOLLES (B., 1921, 59A) is definite, but in some cases the extreme dilution of the impurity, or the possible adsorption of indican during filtration of the water through the soil, renders uncertain the value of a negative result with this test. Better suited to the purpose is the bacteriochemical indole test as described by GERSBACH (Zentr. Bakt. 1922, I, **88**: 145). (A. B. M.).—*A. M. Buswell.*

Potassium Permanganate Absorption, "Chlorine Number," and Chlorination of Water. W. OLSZEWSKI. Chem. Ind., **46**: 3, Jan. 21, 1927; Z. angew. Chem., 1926, **39**: 1309–1310. Determinations of the "chlorine numbers" and permanganate absorptions of a series of artificially contaminated waters confirm the results of FROBOESE and KEISER (cf. B., 1926, 222). For the examination of drinking waters the importance is emphasised of the ratio of the permanganate absorption to the chlorine number in conjunction with the bacteriological examination for the detection of contamination by protein degradation products. For the control examination of swimming-bath waters the permanganate absorption and chlorine number should both be determined. (E. H. S.).—*A. M. Buswell.*

Extreme Lability of Certain Mineral Waters. W. KOPACZEWSKI and A. DE M. SARMENTO. Compt. rend., 1927, 184, 109–111; Chem. and Ind., **46**: 11, March 18, 1927. The variations with time of the pH value, degree of ionization, titratable alkalinity, and iron content of a meso-saline cold water from Vidago, containing 5.33 per cent and 1.13 per cent of sodium and calcium bicarbonates respectively, have been studied. (J. G.).—*A. M. Buswell.*

Producing a Protective Coating in Water Tubes for the Purpose of Preventing Incrustations. C. BÜCHER. (E. P. 260,233; 5.10.26. Conv. 21.10.25): Chem. and Ind., **46**: 15, April 15, 1927. Sufficient calcium hydroxide solution is added

to a drinking water supply containing free or partly bound carbonic acid to produce calcium carbonate. This forms over a period of months a protective chalk lining in the iron pipes, while the hydroxyl-ion concentration is increased above the neutrality point without exceeding the palatable limit. (H. H.).—*A. M. Buswell.*

Behaviour of Active Chlorine Preparations Towards Organic Materials. E. Remy. Chem. Ind., **46**: 15, April 15, 1927; Biochem. Z. 1927, **180**: 97–104. The following antiseptics are placed in decreasing order of their ease of decomposition by organic matter: antiformin (alkaline sodium hypochlorite), hypochlorite (aqueous solution of sodium hypochlorite), caporite (calcium hypochlorite), multisept (mixture of equimolecular amounts of succinic acid and bleaching powder), pantosept (sodium dichlorosulphonamidobenzoic acid), chloramine (sodium p-toluenesulphonchloroamide), and magnocide (basic magnesium hypochlorite). (P. W. C.).—*A. M. Buswell.*

Comparative Chemical Results of Slow and Rapid Filtration (of Public Water Supplies). F. Egger. Chem. Ztg., 1927, **51**: 94; Chem. Ind., **46**: 15, April 15, 1927. Clarification with aluminium sulfate, followed by rapid filtration, is compared with slow sand filtration in the case of river and lake water forming the Stuttgart supply. No advantage was found in adding more than 20 mgm. of aluminium sulfate per litre; 2½ hours was period allowed for flocculation. Oxygen absorption was reduced by 40 per cent, being rather better than with sand filtration; the chlorine figures were similar in the two methods. The bacterial counts in the former method are less satisfactory and chlorination is advisable. Free carbon dioxide, present in the soft lake water, interferes with flocculation, but can be removed by agitation. The taste is considered to be better with the rapid filtration treatment. (C. I.).—*A. M. Buswell.*

Purification of Water. Établ. Phillips and Pain. (F. P. 608,171; 28.3.25). Chem. Ind., **46**: 15, April 15, 1927. A mixture of water with part of the solution of sodium compounds from a base-exchanging purifying plant is treated with lime to precipitate carbonates and bicarbonates. (L. A. C.)—*A. M. Buswell.*

Critical Review of the Methods of Analysing Water, Sewage, and Effluents, with Suggestions for their Improvements. J. W. H. Johnson. Analyst, 1927, **52**: 128–142; Chem. and Ind., **46**: 17, April 29, 1927. Modification of the fundamental organic nitrogen and oxygen-absorption tests are suggested: (1) A modified Kjeldahl process in which nitrites or nitrates do not interfere; (2) an albuminoid nitrogen process carried out under strictly controlled conditions, and with results in relatively close agreement with practical requirements; all acid oxidation processes are condemned. (3) Modification of the Royal Commission test which gives definite results strictly comparable inter se. The results so far recorded of this test are largely the outcome of unnatural conditions, and curves obtained should be strictly rectilinear. (D. G. H.).—*A. M. Buswell.*

Dissolution of Lead by Water in Pipes. A. FARINE. Schweiz. Chem.-Ztg., 1927, 29–32; Chem. Ind., **46**: 17, April 29, 1927. Under similar conditions, distilled water saturated with air, distilled water containing (a) air and carbon dioxide, (b) air and sodium bicarbonate, (c) air, sodium bicarbonate, and free carbon dioxide, when passed at a fixed rate through a tube packed with lead shavings, dissolved, respectively, 110, 10.5, 0.6, and 1.0 mgm. of lead per liter. It follows that sodium bicarbonate exerts a strong protective action which is less strong in the presence of free carbonic acid. The results may be explained by the use of physico-chemical conditions, which indicate that in the presence of insoluble lead carbonate the concentration of the lead dissolved is directly proportional to that of the carbonic acid and inversely proportional to the square of the concentration of the bicarbonate. (W. T. L.).—*A. M. Buswell.*

Notes on Water Analysis. D. BURTON and J. K. HASLAM. Chem. Ind., **46**: 12, 111–4 T, March 25, 1927. The methods for determining temporary, permanent, and magnesia hardness are briefly reviewed in the light of recent literature. Sources of error in determining magnesia hardness are pointed out and a procedure suggested to minimize them. A bibliography of 55 references is appended.—*A. M. Buswell.*

Volumetric Determination of Sulfate in Drinking Water. A. BAHRDT. Z. anal. Chem., 1927, **70**: 109–119; Chem. Ind., **46**: 13, April 1, 1927. To remove the metallic ions in the water a small quantity of sodium hydrogen carbonate is added (to neutralize any acidity) and 300 cc. are filtered through 10 g. of washed sodium permutit contained in a small bulb tube. The filtrate contains only alkali metals together with all the sulfate ions; 200 cc. are neutralised with 0.1 N-hydrochloric acid using methyl orange as indicator and 1 cc. excess of acid is added. After boiling to expel carbon dioxide, 10–30 cc. of 0.1 N-barium chloride solution are added to precipitate the sulfate, an aliquot part of the filtrate is neutralised exactly with sodium hydroxide, and the excess barium chloride titrated with 0.1 N-potassium palmitate using phenolphthalein as indicator. The palmitate solution is standardised against the barium chloride solution and is prepared by adding a 16 per cent solution of potassium hydroxide in propyl alcohol to a warm mixture of 26 g. of palmitic acid, 500 cc. of propyl alcohol, 250 cc. of water, and 0.1 g. of phenolphthalein until a faint pink colour is obtained, filtering, and diluting to 1 litre. The permutit may be regenerated after use by washing with 5 per cent sodium chloride solution then with cold water. (A. R. P.).—*A. M. Buswell.*

A New Specific Color Reaction for Magnesium and a Simple Colorimetric Method for the Determination of Traces of Magnesium. I. M. KOLTHOFF. Chem. Weekblad, 24: 21, 254–5, 1927. The behavior of titan-yellow as acid-base indicator is described; its composition given; its reaction with Mg treated with considerable detail. The paper concludes with a summary in English, as follows. Titan-yellow is a specific and very sensitive indicator for the detection of magnesium. To 10 cc. of the solution are added 0.2 cc. of a solution of 0.1 g. indicator in 100 cc. water and 0.25 to 0.5 cc. of 4 N sodium hydroxide. In the presence of magnesium the yellow color changes to red. Sensitivity

0.2 mgm. Mg per litre. Calcium salts deepen the red color. The reaction is very suitable for the colorimetric determination of traces of magnesium in, for example, tap water. The best color scale is obtained with solutions containing 4 to 0.4 mgm. Mg per litre. If the solution to be investigated contains calcium, the color standards are prepared in solutions of magnesium which contain about 100 mg. calcium per litre.—Aluminium and tin have a disturbing effect.—Zinc can be made harmless.—*Frank Hannan.*

NEW BOOKS

CO_2 Meters (Electrical). Leeds and Northrup Company, Bulletin 781, 1927. An electrical CO_2 meter, based on the thermal conductivity method, has been developed for boiler room use. In the thermal conductivity cell the construction of the gas passages makes the flow of gas through the cell itself independent of the rate of flow in the sampling line. Gas is drawn through the cell by a convection current set up by the heat of the platinum wire, which is held at practically constant temperature. The standard gas chamber and flue gas chamber are mounted in same metal block, so that they are at substantially the same temperature. With exception of platinum wire, all metal parts exposed to flue gas are heavily gold plated to protect them against corrosion. Flue gas passes through primary filter to water-sealed drain, then to calcium chloride drier. The gases then go to the cell through a porous earth thimble, to remove any remaining dirt, moisture or acid mist. Bulletin also contains discussion on economic significance of excess air, and curves showing control of combustion, effect of hydrogen in fuel, excess air and flue gas temperature and loss due to excess air.—*A. W. Blohm.*

The Financial Limitation in the Protection of Reservoirs. W. W. Ashe. United States Department of Agriculture, Bulletin No. 1430, August, 1926. This bulletin shows that with storage there enters the problem of siltage through erosion of soil, an insidious agency which may cause loss of pondage and consequent reduction in the capacity of reservoirs. The rapidity of erosion and of silting up of reservoirs is affected by different physical and meteorological conditions in the different regions of the United States. Over the greater portion of northern and northwestern United States and in Canada erosion is not the serious problem that it is in parts of the Southeast, and particularly in portions of the Southwest. Attention is called to the high silt burden of certain streams and the rapidity with which storage capacity of reservoirs is reduced, as in the case of the Colorado River (of Texas). The reservoir at Austin on this river lost more than half its capacity within ten years. Many other streams carry a silt burden fully as great as that of the Colorado. On the basins of certain of these streams the surface conditions are such that erosion can be materially reduced. On others the conditions are such that erosion can be only slightly lessened. On these it is a natural condition—the result of surfaces which are naked of protective vegetation on account of irregular rainfall, yet which are subject to excessive erosion of soil, because the limited rainfall is of a heavy and most concentrated type. There

are other regions where protection of the surface is highly efficacious in reducing erosion. It is shown that it is possible to ascertain the rate of silting which is taking place and from this to determine the capital value of the storage capacity, the loss of which might be expected within a given period. It is also possible to determine the extent to which excessive erosion may be checked by artificial means. The author proposes a formula for determining how much money could be economically expended to maintain this capital value, which otherwise would be destroyed by siltage. He points out that in case woods are artificially established for the purpose of securing soil cover and reducing erosion a definite return can be expected from the investment therein, but that power and water companies are justified in making additional expenditures which would be within the capitalized value of the storage capacity which will be preserved. In the Southern Appalachians as well as elsewhere there are alluvial lands which have been injured during floods by gullying or by the deposit of sand and gravel. Where such conditions exist there is an opportunity for the establishment of settling basins. The settling basins proposed would not only result in the elimination of much silt from the stream, but also would bring about the rehabilitation of the devastated lands, which after being built up by deposit of the sediment would again be available for farming. Since this sediment as a rule consists largely of the most fertile soil eroded from the surface of the watershed, areas thus built up would be very fertile. A number of illustrations show the effect of vegetation in the protection of soil from erosion and the surface conditions both in regions subject to erosion and where it is possible to reduce it and in regions where such protection is not effective. Copies of the bulletin can be obtained from the Forest Service, Washington, D. C.—*A. W. Blohm.*

A Treatise on Hydraulics. Hector J. Hughes and Arthur T. Safford. Revised and abridged by Safford, 1926. The Macmillan Company, New York, N. Y. In revising this book the authors state that an attempt has been made to decrease the size of the original volume, but at the same time retain most of the material. Some additional data have been added, however, to bring the work up-to-date.

The first chapter is devoted to a history of hydraulics in which brief mention is made of the works of various contributors to this branch of science. Knowledge of hydraulics has gradually increased in the course of centuries until by 1800 it was approaching an exact science. Out of all the work and thought devoted to this subject during the past two thousand years, certain basic principles and formulae have been evolved which, with slight modifications, are the laws still governing the flow of water.

The subjects discussed in the book are hydrostatic pressure, hydraulic flow, the measurement of water in pipes, conduits and open channels, and a brief discussion on water-wheels and pumps. At the end of each chapter, a series of problems based upon the text are listed which make the book of value for classroom use.

The volume is intended primarily as a textbook of hydraulics and no attempt has been made to cover the more complicated problems met with in actual

practice. The authors believe, however, that these can be resolved into their individual parts and solved by the various methods covered in the text.

The material is well arranged and easy to follow. The various mathematical computations are not involved and the solutions follow readily. While the book can be used principally as a textbook of hydraulics, it will be found of considerable value as a reference book to the practising engineer.—*George L. Hall.*